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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT JANUARY 11, 1960

R & D GROUP WITH FUEL-CELL TRACTOR

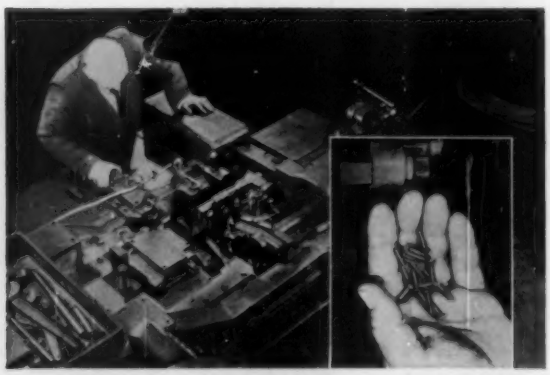
...see page 3

Which picture do you fit?

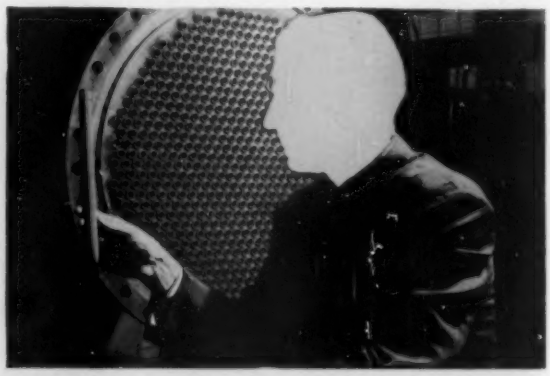
Here are four *actual* customers* with different, but exacting product and technical needs. One uses Bridgeport rod in a range of alloys, the second Bridgeport strip. A third makes fasteners from Bridgeport Brass wire. The fourth company uses Bridgeport condenser tubes *and* Technical Service to produce quality heat exchangers. Which picture do you fit with your raw materials and manufacturing requirements?

"AUTOMATIC QUALITY," says Customer A. "We've a high-volume, automatic screw machine operation. Our alloy needs vary from job to job. Our production schedules demand *consistent* quality alloy and accurate gauge. With every rod alloy we get from Bridgeport, we get what we order . . . including aluminum alloys!"

"LONG-LENGTH COILS. They're one reason why we can depend on Bridgeport for strip," says Customer B. "Superior surface finish from Bridgeport saves us production costs. With their Sendzimir mill finish and exact gauge and width in long-length coil, you can see the reasons why we depend on Bridgeport for brass, copper and aluminum strip."



"CONSISTENT GAUGE. We need Bridgeport quality brass wire to make thousands and thousands of fasteners of every description," says Customer C. "High-speed, volume cold-heading production is only as good as the alloy wire that's used. Bridgeport Brass wire is made to exact tolerances for cold-heading at high speeds—we depend on it."



"PRODUCT PLUS SERVICE," says Customer D. "We manufacture heat exchangers for many applications. Our requirements include good technical and engineering service as well as a wide choice of brass, copper and aluminum tube alloys. All of these are available from Bridgeport."

*Names on request

These examples typify national metalworking opinions. There's no mystery why manufacturers the country over depend on Bridgeport—Bridgeport products and service are *close at hand.* The many brass, copper and aluminum alloys made by Bridgeport in rod, tube, wire and strip are *readily* available from stocks in your area; Bridgeport warehouses are located to make it easy for you to get what you want on time. Volume needs are mill-delivered. Your call to your nearest Bridgeport Sales Office, or a letter to Dept. 3601 will get you engineering and technical service. Try it, and you'll agree —you do fit into the picture!

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

January 11, 1960 Vol. 31, No. 2

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A Tiny Producer, the honeybee, is equally famous as a supplier of a favorite delicacy and as a pollinator of valued crops. Worker bees — the only nectar-gatherers, honey-processors and home-builders — are always the smallest members of their colony. About ½" long, they're considerably smaller than drones.

Small Pain-Reducer. In this newest dental handpiece, tiny MPB bearings permit the head to be miniaturized for easier use and better visibility, particularly with children. The MPB bearings used here must withstand punishing acceleration from 0 to 250,000 rpm in a half-second, the speed necessary for comfortable, quiet drilling.

Man With Miracles. Every day MPB Sales Engineer Ray Armstrong helps industrial and scientific engineering staffs to select miniature bearings that reduce friction and increase accuracy of instruments and other devices. An MPB sales engineer is always ready to help you develop the miniaturization your products need.

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ACTUAL SIZE OF THE MPB BEARINGS IN DENTAL HANDPIECE SHOWN ABOVE

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INTERESTING TO NOTE

Asphalt and Battery

Digging in the ruins of Khujut-Rabua, a suburb of ancient Baghdad, archeologists recently unearthed a clay vessel whose unusual contents set them to puzzling. In it was an upright cylinder of pure copper which, in turn, surrounded an iron rod. The entire vessel was filled with asphalt. The iron rod was found intact where it projected above the asphalt layer, but the submerged end was badly corroded, as if by acid. Physicist George Gamow suggests this was not a haphazard combination of materials, but an early electric battery. Dr Gamow believes it was used by Arabian jewelers to electroplate their wares with thin coatings of gold or silver. If an electric battery did exist in the first century BC, not only were Galvani and Volta beaten by 2000 years, but also the charming damsels of Arabian Nights fame were the first women in history to wear electroplated jewelry.

In the battery sense of the word, that clay vessel from Baghdad may have been the first fuel cell. Our cover picture shows the latest fuel cells developed at Allis-Chalmers Mfg Co, under the supervision of Dr H K Ihrig, vice-president in charge of research, and Will Mitchell Jr. assoc director. The unit shown is powerful enough to run a tractor. If you think the tractor's testing ground looks like a golf course, you're right. Allis-Chalmers bought the land from the town and built a private course for its employes.

The Secret of Murano

Until the mid-1600s, all plate glass came from the tiny island of Murano near Venice. There, glass-making was a rare and closely guarded art, and the men responsible for producing glass plate and decorative mirrors were held captive. If a gifted artisan defected from Murano, his family was immediately held as hostage. If he was recaptured, the penalty was death, with no appeal.

As glass prices rose, only royalty could afford plate glass and mirrors. Glass soon became symbolic of wealth and power. Louis XIV was espescially fascinated by the wonders of glass-making. He'd stand for hours before his mirror in self-admiration, dreaming of a glittering palace worthy of his glory. Through liberal amounts of gold, Louis XIV managed to bribe a small band of Murano glass-makers and established a plant near Paris. Later it was moved to the abandoned St Gobain estate in a dense forest.

In Murano and Venice there was panic! Agents sent to Paris poisoned two of Murano's expatriates, but it was too late. France already had the secret, and King Louis' dream of a Hall of Mirrors became a reality.

Not to be outdone, Russia's Peter the Great wanted a similar hall for himself. France's new industry soon filled his order. The artisans at St Gobain completely over-

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shadowed the glass makers from Murano and the monopoly ended.

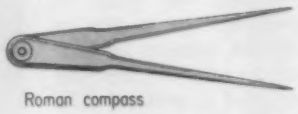
A contemporary mystery concerning glass involves one of its modern forms—glass fibers. For designers, choosing the right process for making fiberglass-reinforced plastic parts may sometimes seem to require occult powers. The article on page 47 supplies the key.

Drafting Through the Ages

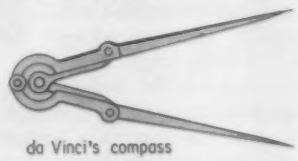
An interesting booklet, "Historical Note on Drawing Instruments," (free on request from V & E Manufacturing Co, Pasadena, Calif) shows that drafting instruments have changed very little during the past 20 centuries. Today's instruments are more accurate but in appearance there hasn't been much change.

Pencil and paper were unknown to the earliest Roman draftsmen. Instead they worked with metal instruments, usually bronze. These inscribed directly onto wooden tablets coated with wax or, if the drawing was to be a permanent one, upon papyrus or animal skins. The Roman pen was usually made from a hollow reed cut to a flat point on one side and slit like a modern pen. The compass looked very much like a pair of present-day dividers; a bronze rivet held the two compass legs tight enough to keep them at any desired setting. Circles were scribed with bronze points.

The next 1500 years saw virtually no change in drafting instruments despite the introduction of paper to the Western World and the change from reed pens to quills. Around da Vinci's time (1452-1519) the silver point method of marking paper was developed. Paper was prepared by applying a wash consisting of finely ground pumice held in a dilute solution of glue or flour paste. When dry, drawings could easily be recorded by scratching the paper. Da Vinci started with a silver pointed stylus, then went over the drawing with pen and ink.



Roman compass



da Vinci's compass

Modern compass

The evolution of drafting instruments to the present day has been a very slow process. Better materials increased instrument life while improved papers and inks added a higher degree of accuracy. Paper has always been an important factor in preparing drawings. While the appearance of instruments themselves may have changed little, the improvement in drafting paper throughout the years is undeniable. On page 40 a drafting method is discussed that gives a third dimension to drawings by making use of a series of grids.

—Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Fluids for Power and Control**
A practical guide to choosing and using the right hydraulic fluid; summarizes the basics and supplies charts of typical properties.

. . . **Measuring Moment of Inertia**
8 oscillating and "falling weight" setups combine with simple formulas to give answers for complex shapes.

. . . **When Fungi Attack Your Product**
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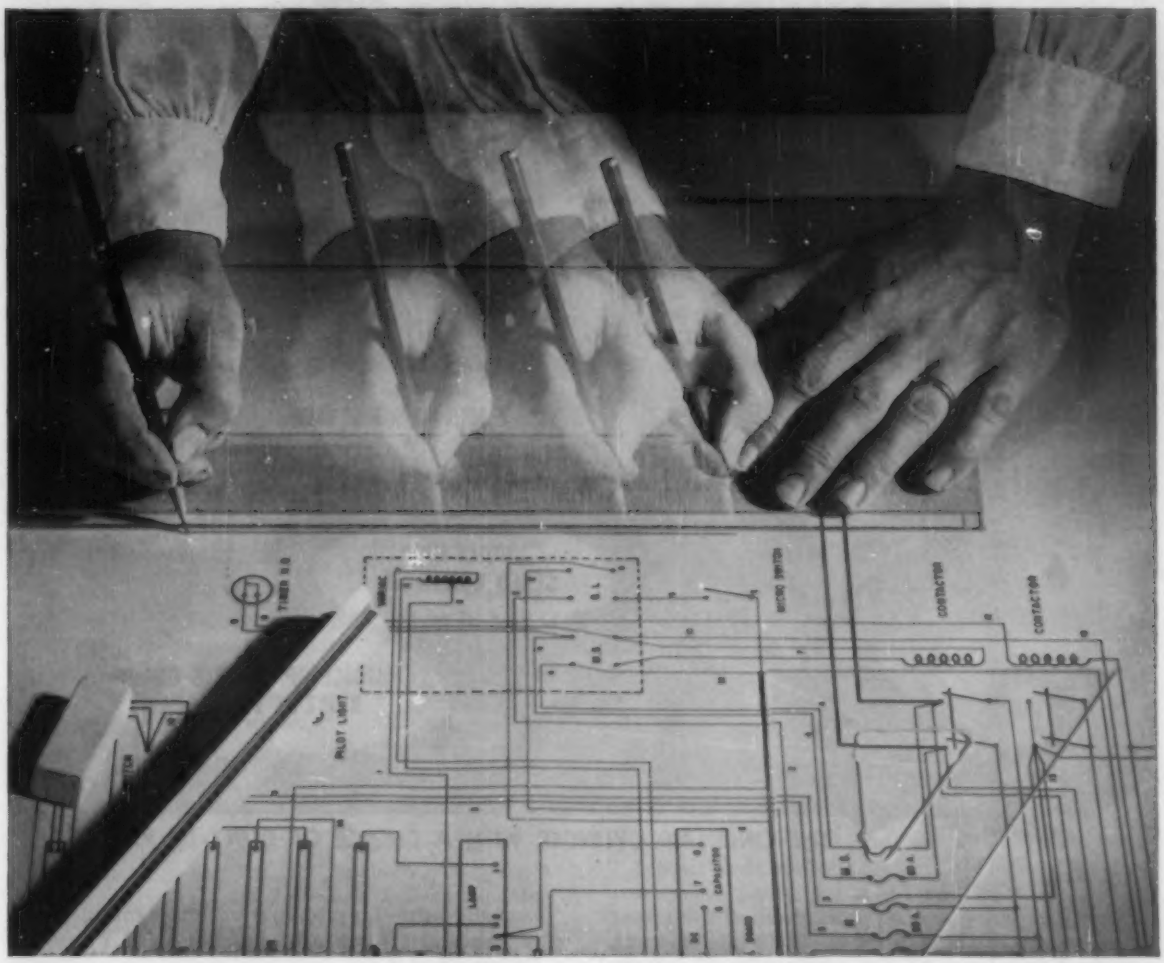

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DEVELOPMENTS TO WATCH . . .

A machine to measure standard deviation . . .

. . . has been developed by American Machine & Foundry. Designed specifically for quality-control systems, it's an electronic counter and recorder that weighs individual items, compares their weight with a preset control value and then computes the standard deviation—all in "1/100th of the time required by ordinary methods." It's a self-contained console-type unit that can be moved to the job and plugged into any outlet. Results can be presented on chart, meter scale, or paper tape.

First application of the new device will be in cigaret-making where, AMF says, the machine will be able to check a 2000-cigaret sample in less than 2 min.

A decade counter will monitor the number of cigarets weighed. Then, the signal output of the measuring head will be proportioned to the deviation from the preset value. A calibrated meter with "suitable squaring and integrating amplifiers" will perform the required calculations (squaring the deviation of the individual cigarets from the preset value, dividing by the number counted, and obtaining the square root of the result).

Titanium scrap can be converted . . .

. . . into metal of higher strength and better ductility than the original wrought product, a Watertown Arsenal study indicates.

When titanium alloy scrap is embrittled by hydrogen, pulverized, and powder compacts are vacuum sintered to theoretical density, they show strength equivalent to the wrought metal, but lower ductility. However, when this material is hot roll-reduced even 35%, strength and ductility start to climb; and a roll reduction of 65% produces metal that not only exceeds the original wrought metal in strength and ductility at room temperature; but also in 800-F tests. The roll-reduced metal shows excellent stability as well.

Concludes S. V. Arnold of Watertown, titanium alloy powder handled in this way has "interesting structural potential."

Bacteria and fungi may affect joint seals . . .

. . . in gas pipelines, a survey by Institute of Gas Technology indicates. The Institute has been conducting a broad-gage survey of pipe leaks and leak-detecting systems and finds that "leaking joints may contain a range of materials such as impervious, hard residues and loose, dry jute fibers."

Jute deterioration, the Institute says, is caused in most instances by the chemical attack of acid constituents in the gas. However, biological attack is possible in systems that have been operated for long periods with natural gas which contains no bactericidal or fungicidal agents and in which the humidity is high enough for bacterial or fungal growth. Next step is study of sealants and sealant methods to get around this problem as well as provide for greater protection against leakage.

(Note: For more on fungus control, see next issue.)

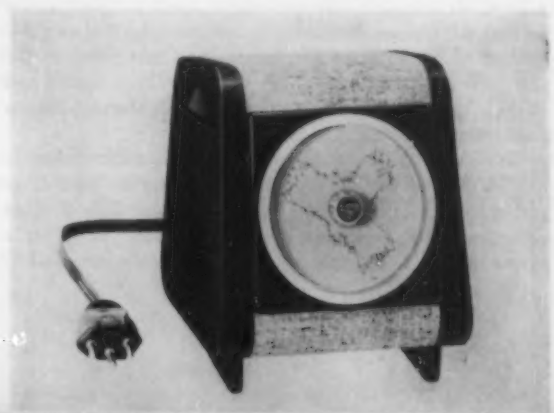
Another recent institute finding: For locating leaks in underground piping, sonic methods "offer the greatest promise for further research and development." Tests in the laboratory with a small leak in a pipe covered by 12 in. of sand show that location of a leak can be determined from intensity of the sound produced by the escaping gas. To prevent interference by background noise, the institute is developing a new system involving generation of a sound tracer signal inside the piping. This way, the institute says, "the intensity of the tracer signal detected at the surface is many times greater than background sounds anticipated in the field."

Work is continuing on both problems and reports will be issued as studies are completed.

Miniature printing recorder less than 4 in. square . . .

. . . for panel-mounting or portable use is being introduced by Elmes, Staub & Co, Richterswil, Switzerland. Using pressure-point recording on special paper (no ink or ribbon), it has a 6-sec scanning system, provides an immediately visible display.

(Note: For other new recording devices, see *PE*—Dec 28 '58, p 8 and 10.)



Midget recorder is said to be unusually sturdy. This is the Elmes portable model.

Materials that change color under stimulation by sonic pressure . . .

. . . and other energy sources are being developed at Electroflor Inc.

Fluids and gels that become opaque under electrical stimulation have already been developed by this company and others (*PE—Jan 13 '58, p 5*). But Electroflor is now exploring such possibilities as 3-dimensional data displays. A unit of this type, Electroflor says, might be made by filling a transparent cubical container with a pressure-sensitive liquid. Sonic transducers, impinging on 3 sides of the container, would respond to information signals and could transmit energy pulses. These could be so timed that they would intersect to produce a color dot, intensity of which could be governed by the signal amplitude.

Electrostrictive driving elements for electromechanical devices . . .

. . . are being developed by Clevite Corp under Bureau of Ships contract. The research is still in the very early stages, and no information is likely to be available before March or April; but present plans call for design of prototype relays and meters operated by both piezoelectric and electrostrictive elements, and development of new and improved materials. The work is being done by the company's Electronic Research Div in Cleveland.

Best design for shaft seals . . .

. . . for operation at speeds in the 20,000-rpm range and temperatures to 1000 F is the circumferential type, using an oxidation-resistant carbon (graphite) for the stationary member and carbide (tungsten, titanium, or chromium) or aluminum oxide for the rotating member.

That's the key recommendation of a WADC report on a long-term study in which more than 150 possible material-and-design combinations were tested.

Coming in a poor second to the circumferential design is the face-type seal. Here what seems to be the best combination is titanium carbide (for the stationary member) with aluminum oxide or one of the other carbides for the rotating member. But design must compensate for the limitation on axial shaft travel imposed by this configuration.

Many other materials showed ability to withstand rubbing wear, mild thermal shock, or oxidation under the specified conditions; but those listed above gave the highest performance.

Says WADC:

- Almost all carbides, nitrides, and borides except boron nitrides passed the rough screening test.
- Most high-temperature alloys were able to resist oxidation and thermal shock, but only the Stellite alloys showed acceptable wear resistance.
- The stainless and tool steels showed either good wear resistance or good oxidation resistance; but none were acceptable in both respects. Furthermore, nitriding decreased the oxidation resistance of all the steels to which it was applied.

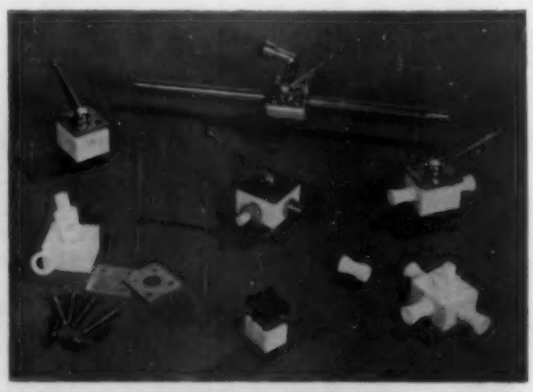
An 88-page report, prepared at the conclusion of the second phase of the program (WADC #56-267, pt II) will shortly be available through OTS, Dept of Commerce, Washington 25, D. C. Expected price is $2.

Valves that require no lubricant, packing, or sealant . . .

. . . and have "only one moving part, one material in the path of the fluid," have been designed for corrosive service by Watson-Marlow Air Pump Co, Buckinghamshire, England.

Major material of construction is Teflon—which is resilient, resistant to chemicals, and self-lubricating. The valve is so designed that the plug is held in compression instead of tension and sealing pressure is downward—towards the bottom of the barrel—and is applied to the shoulder of the plug. The resulting "squeeze," says W-M, "ensures that contact between plug and barrel is uniformly intimate."

The valves will operate in vacuum or under pressures to 250 psi and can be supplied with a variety of fittings and adapters. Price range will be about $28.30 (US equivalent) for ¼-in., two-way valves; about $210 for a 1½-in. valve. —ARG



For corrosive service stainless steel and PTFE plastic are combined in simplified valves designed for easy assembly.

WHAT'S HAPPENING IN RESEARCH . . .

Focused sound waves for research

To produce high-intensity beams of ultrasonic energy, Soviet scientists have designed a focusing shell that produces, at its center, a beam intensity on the order of 70 x 10^8 w/cm^2 and a sound pressure in the order of 500 atmospheres.

The device consists of a half-wave resonant aluminum shell (flare angle 70°; ID 12.3 in.) studded on its outer surface with some 200 silver-plated piezoelectric quartz disks (each, 1.6 in. in dia). The shell is flanged for support, filled with deaerated water for cooling, and provided with two observation ports.

The quartz disks are connected by a system of channels through which current is fed from an 8-kw oscillator.

Airgaps behind the disks help increase oscillation amplitude. To prevent flashover, the silver plating on the disks stops short of the rim.

The Soviets expect to use the device to study sonic "wind" cavitation, and related phenomena.

What causes swelling of metals?

Swelling of uranium under neutron irradiation has long been recognized as a serious problem in nuclear reactor design and operation. But it now seems that' not the only metal that is affected.

In reports to the Metallurgical Society of the AIME, British researchers note that aluminum, copper, beryllium, and magnesium also expand when irradiated, and they now offer an explanation for the effect:

Essentially, they say, swelling results from creation within the metal (by neutron-induced fission and transmutation) of such inert gases as helium, xenon, and krypton.

At room temperature, these gas atoms simply remain where they are and cause little trouble. But, as the temperature rises, they tend to agglomerate and form bubbles which, unable to escape, gradually swell the parent metal—sometimes increasing volume as much as 25%.

This explains why swelling sometimes occurs *after* irradiation instead of just during exposure. Any heat treatment, by raising the temperature, encourages agglomeration of the gas atoms already present, and swelling begins.

Best preventive so far, if heating cannot be avoided, seems to be pressurization. Says R. S. Barns of UKAERE at Harwell, England, "excessive volume increases can be prevented by the ambient pressure exerted upon the material." Pressurization at 17 atm will hold swelling to about 5%.

Previewing silver bearing performance

Two test methods that can help predict performance of silvered bearings and provide advanced data on corrosion by lube oil additives are being described at this week's SAE Annual meeting by L. O. Bowman and M. W. Savage of California Research Corp.

They point out, "uncompounded lubricating oils usually have good silver lubrication properties. Certain lubricating oil additives, however, exhibit undesirable silver lubrication performance . . . and commercial inhibitor additives that do not corrode silver are, almost without exception, less effective as inhibitors than common sulfur-containing inhibitors such as the dithiophosphate types."

The two tests, they say, provide extremely helpful information. One is a bench test in which a silver strip is weighed, then immersed in the test oil, which is heated and agitated. Test duration is 20 hr, after which the silver strip is cleaned and reweighed. The weight loss indicates amount of corrosion that has occurred.

In the other test, weighed silver-plated connecting rod bearings are run for 300 hr at moderate speeds and loads (following the MIL-P-17273 procedure) and then cleaned and reweighed.

A surprisingly good correlation was obtained between the bench and engine tests, except at very high corrosion values.

However, the California researchers note that oils which perform well in these tests and in this type of service may not be at all satisfactory for bearings like diesel engine wrist-pin bearings which operate under boundary lubrication conditions. All five oils which passed the engine test failed in the Kinetic Oiliness Test, specifically designed to test silver-on-steel friction performance; so bench and engine tests should not be the sole guide here.

brief . . .

The aluminum-silicon eutectic contains 12.7% Si at 1070 F, not 11.7 and 12.5 as previously reported, R. A. Meussner of Naval Research Lab claims. His studies indicate that previous determinations, based on extrapolations of thermal analysis data, were in error. A report on his work is now available from OTS, Dept of Commerce, Washington 25, D. C. It's PB 151,735, 12 pp, 50¢. ARG

Miniature aid for computers

Baby data-printer, about the size of a cigaret package, is designed to take the place of bulky electric typewriters in computer read-out systems. Built by engineers at NYU's Research Div, it uses electrosensitive paper, does its printing by energizing stainless steel printing segments which can produce as many as 20 digits simultaneously. It's one step toward development of a complete miniaturized automatic data system, on which NYU is now working.

1 The handle of this automatic fry pan is molded of phenolic to:
(a) stay cool *(b) fit small hands*
(c) insulate inner wiring

2 In 18 years, it's been re-coated with phenolic paints:
(a) 2 times *(b) 5 times*
(c) 9 times

Can you pass this test on Phenolic Plastics?

(You'll discover more of their potential as design materials)

3 This modern electronic circuit is *printed* on a base of:
(a) molded phenolic *(b) phenolic-impregnated paper laminate*
(c) phenolic-coated metal

4 These smoother-finished metal castings result from:
(a) phenolic-bonded shell molds *(b) phenolic-based coatings*
(c) phenolic-bonded grinding wheels

5 This device to test vision has a molded phenolic case that:
(a) cuts weight 50% *(b) needs 25% less tooling*
(c) requires no coating

ANSWERS... *to design and production problems throughout industry are found in dependable BAKELITE phenolic plastics.*

1. Check (a) and (c), and add durability.
2. (a) Twice—phenolic paints last 7 years on the San Francisco Bay Bridge.
3. (b) A laminate—machineable, chemically inert, and non-conductive.
4. (a) Lightweight shell molds that virtually eliminate machining.
5. Check (a), (b), and (c)—it saved all around.

If you have questions—about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. AX-05D, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

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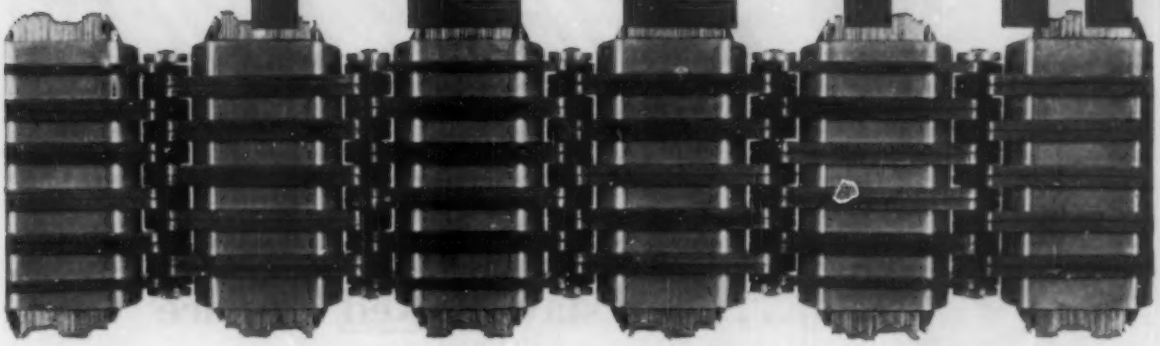
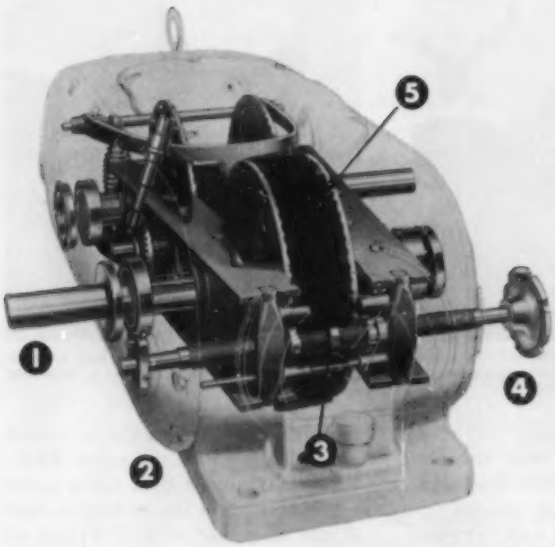
PUT TEETH



IN YOUR SPEED CHANGING JOBS



Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

BOOK 2274—Your Link-Belt office has Book 2274 on P.I.V. drives ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.

(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage —give the speed you need at any setting.

15242

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

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P.I.V. VARIABLE SPEED DRIVE

CIRCLE 11 ON READER SERVICE CARD

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Why cap screws instead of studs?

Many types of products once fastened with studs are today assembled with cap screws. Why the change in preference?

Studs show certain advantages in large diameters and in high temperature applications. But when it comes to smaller sizes used in tapped holes, designers and production people have found more advantages in cap screws.

ASSEMBLY FACTORS

In fastener selection for a given application, you have to consider production and assembly as well as joint strength.

Obviously, studs require two wrenchings (first stud, then nut). Also, there's a more expensive close tolerance tapping job, since a stud takes an interference fit to stay tight and not withdraw when nut is backed off.

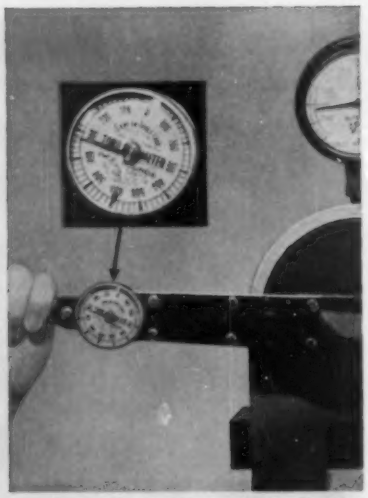
Cap screws require only a clearance fit. Used in a tapped casting, they can be repeatedly inserted and unscrewed without damage to threads.

HOW NOT TO USE STUDS

Studs are not meant to serve as dowels to locate and line up for fastening. To line up numerous studs and bring two pieces together raises assembly cost. Use dowel pins for alignment and use cap screws for fastening to achieve greater economy.

Screw develops high thread tension . . . and stays locked in place

RB&W TENSILOCK screw, despite the friction at the toothed flange, develops 4000 pounds tension with on-torque of 240 inch-pounds.



An off-torque of 330 inch-pounds fails to break loose the grip of the teeth. Tension is maintained by TENSILOCK screw.

Here is a locking fastener where the on-torque effort not only *anchors* the screw but also develops high preloading, or residual tension.

Like high tensile cap screws, RB&W's TENSILOCK* screws also give a high thread tension to torque ratio. But there's one important difference. The TENSILOCK fasteners lock with *teeth* as well as high residual tension.

RATCHET-LIKE LOCKING

Carburized teeth on flange of this one-piece fastener are so angled as to afford easy torquing. They bite into the seating surface when fastener is fully tightened. A circular groove in the flange increases flexing action and enables flange to maintain pressure on the imbedded teeth. To *loosen* a tightened TENSILOCK fastener thus takes much more effort than the on-torque. And it can be reused with little loss of this holding power.

FRICTION STOPS SLIPPAGE

The full clamping force exerted by these fasteners prevents slippage of the fastened members where lateral movement is possible because of large or eccentric holes. The positive gripping enables them to stay tight even under conditions of severe vibration or cyclic temperature fluctuations. RB&W TENSILOCK nuts also available. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*Trademark Pat. applied for

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

FROM WASHINGTON . . .

Research and development spending in industry facilities up almost 160%

In the past six years industry spending for facilities has jumped from $3.6 billion in 1953-54 to an estimated $9.4 billion in 1959-60. This is a major conclusion in a new analysis of R & D expenditures by the National Science Foundation.

NSF reports that total US spending for R & D has zoomed from an annual total of $5.1 billion in 1953-54 to a rate of at least $12 billion in 1959-60.

Industry has done most of the R&D spending but Washington has supplied most of the funds. In the past six years, the federal government has almost trebled its allocation for R & D—from $2.7 billion to $7.7 billion. At the same time, industry has only doubled the amount of its own money it spends to sponsor its R & D efforts—from $2.2 billion to $4.4 billion.

The swing in industry-government shares for R & D has been a sharp one: from 60% industry–40% government in 1953 to a current split of 60% government–40% industry.

Pentagon is accelerating phase-out of manned aircraft

More signs of phase-out of manned aircraft show up in the Air Force's latest decision to chop 30 KC-135 jet tanker planes from the original order of 96 for the current fiscal year. The plane is built by Boeing Airplane Co for aerial refueling of SAC bombers. It was the military prototype for Boeing's 707 civilian jet.

The KC-135 cut was made, says the Air Force, to keep its logistic craft in line with the bomber program. Earlier, the Air Force cut 12 planes from its 32-plane order for Convair B-58 medium-range supersonic bombers this year. A stretchout for Boeing's B-52 heavy bomber has also been worked out.

Each of the Air Force's aircraft cuts reflects the Pentagon's toughened economy drive. Savings on the KC-135 cutback will total about $97 million. The B-58 reduction will mean a $240-million budget saving.

In effect, the Administration's tight budget policies are forcing the Air Force to speed the transition from manned planes to missiles at a much faster rate than the Air Force strategists want.

What rankles Air Force brass more than anything, however, are earlier decisions to cancel the project to develop the F-108 Mach 3 fighter-interceptor and to cut the B-70 bomber project. These were the future generation of manned combat planes. As the situation stands now, the Air Force has no serious plans to replace current aircraft models with advanced versions in the near future.

Engineering graduates will double by the late 1960s, says Labor Dept

New government handbook forecasts that the number of engineering graduates will double by the late 1960s, that employment prospects for engineers on an over-all basis "will continue to be favorable through the early 1960s at least."

This is what the Labor Dept has to say about engineers in the latest edition of its famed "Occupational Outlook Handbook." This is the bible for vocational advisers and career guidance counselors throughout the country.

In general, the handbook also predicts a favorable employment outlook for scientists, but hedges the forecast this way: "Future trends of employment in the sciences will be influenced primarily by two main factors—the demand for college teachers and the amount of expenditure for research and product development."

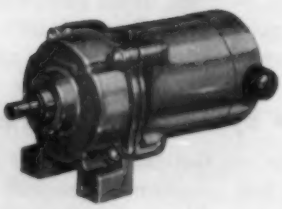
The door to your motor department...

27 Volt DC shunt wound aircraft motor qualified to specification MIL-M-8609A (ASG) for small high speed pumps. Frame 1²⁵/₃₂ x 1⅛

Impact drill motor for putting threaded inserts in concrete. Designed to withstand heavy vibration. Frame 3¹¹/₁₆ x 1¾

Two-stage helical gearmotor with crank on output shaft to operate circuit breaker. Frame 2⅞ x 1½

¾ Horsepower motor with two-stage fan, Underwriters' labeled for explosion-proof vacuum cleaners.



Differential planetary gear train allows for unusually compact design in this miniature gearmotor for business machines. Frame 1⅝ x ¹⁵/₁₆

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8-page Folder describes these and other Lamb Electric motors. Send for your copy.

We work so closely with customers that many consider our facilities a part of their own operations.

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THE ENGINEERING WEEK

EPA—What It Means to Europe's Engineering Potential

PARIS—US industry traditionally has developed machines and technology to increase worker productivity. Europe, in contrast, has traditionally feared such innovations as a threat to employment. The European attitude of caution is now undergoing profound change, thanks to the European Productivity Agency. Europe is well on the road to becoming a rich production area where good engineering is combined with mass production and distribution techniques. (*PE*—Dec 21 '59, p 21).

EPA, founded in June, 1953 as a loose affiliate of the Organization for European Economic Cooperation, has 18 member countries and a budget of $3 billion a year. To achieve its aim of spurring economic activity, EPA has become involved in such diverse projects as an experimental low-shaft blast furnace, techniques for shipping fresh fish, and rejuvenation of the economy of Sardinia. These efforts have paid off. The latest report of the OEEC showed that industrial output of member nations rose 31% between 1953 and 1957.

EPA has so broadened its activities that reorganization is pending for next June. Under the proposed new setup, the Office of Scientific and Technical Personnel, established in May, 1958 to increase supply of scientists and engineers, will be consolidated with EPA. The new agency will concentrate on improving European science and technology and aiding underdeveloped areas on the continent.

EPA originally placed greatest emphasis on getting immediate production gains at plant level. This was accomplished in part by sending technical and managerial personnel to the States to observe American practice. Now, EPA is more interested in long-term results.

MORE APPLIED RESEARCH

The Productivity Agency is stressing applied research as a means of increasing productivity. It is encouraging more European research facilities and coordination of their activities. A study currently underway will provide information on how members finance, organize and administer research. Another study will seek financial inducements, such as tax relief, for building new facilities.

In its joint research, EPA is concerned with guiding cooperative research. On the basis of such studies, eight member countries along with US are now ready to make fatigue tests of 6000 light-alloy and 8000 steel specimens (*PE*—Aug 17, '59, p 23).

GOOD INDUSTRIAL MANAGEMENT

Business management projects dominate the budget. Much of the allotment is spent on conferences, seminars and demonstrations by teams of experts to keep European managers abreast of developments in cost control, job analysis, distribution techniques, quality control, and warehousing.

Considerable funds are allocated to so-called "pump-priming" activities. These include sending business school professors to the US and inviting US professors to Europe. Such exchanges are not always without friction. One productivity survey of Europe's machine tool industry by a Columbia Univ professor last summer (*PE*—Oct 12 '59, p 39) drew the Europeans' fire. It concluded that the USSR with mass-production techniques for manufacturing machine tools, could undersell the West and blamed Western-European management for insisting on status quo of low productivity and high prices.

AUTOMATION GOES EUROPEAN

EPA is an ardent missionary of automation. In its trade union activities, the agency is trying to smooth transition to automated production through study groups that explore impending problems for both labor and management. A related human factors study is concerned with fitting jobs to workers. Still another aims to protect workers from radiation hazards resulting from isotopes.

One of the most valuable projects undertaken by EPA is economic development of "underprivileged" Sardinia. Since 1956, a team of experts has been working on the economy of a 420,000-acre pilot area. Agricultural experts are increasing output of three basic products: wool, olives and wine; marketing specialists are organizing cooperatives to handle sales and encourage exports; and productivity experts are encouraging wool weavers to shift to new looms. Concurrently, a program is underway to improve schools and sanitary conditions.

—Art Erikson

Cost-reduction Program Pays Early Dividends

FARMINGDALE, NY—Republic Aviation Corp reported a saving of over $25 million in costs of producing the F-105D airplane, after only eight months of a program aimed at cutting 30% from the initial estimate. Taking part in the project are 831 companies from 30 states.

Republic's director of material, E. I. Little, noted that there is a 19.9% reduction so far. In addressing a conference held at Republic, Little cited savings in these five areas.

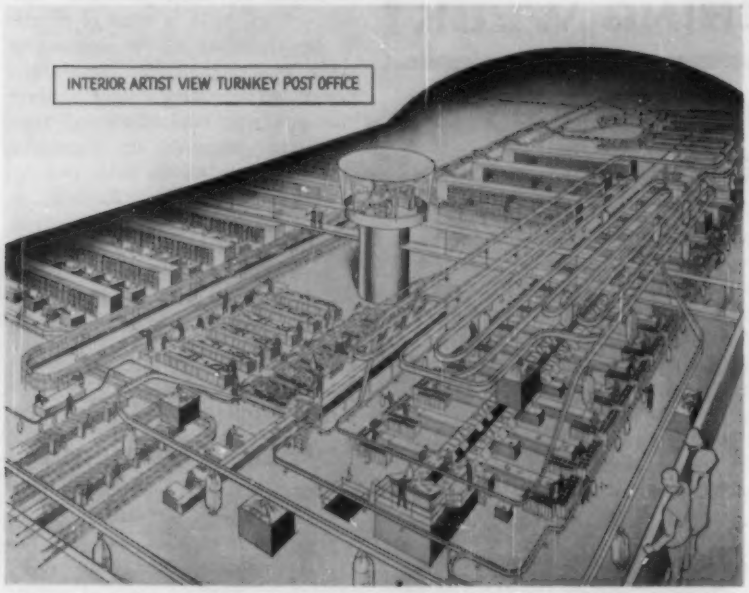
- Subcontracting, $2¼ million (15.5%)
- Equipment, $3½ million (12.9%)
- Electronics, over $3 million (21%)
- Raw materials, $9½ million (16.6%)
- Government-furnished equipment, $6½ million ($21.6%)

RELIABILITY DEMANDED

Maj Gen Beverly H. Warren, commander, Aeronautical Systems Center, Air Materiel Command, told the gathering, "Unreliability, production difficulties and engineering changes are major factors causing high costs in today's weapons systems." He emphasized that unreliable, short-lived systems, subsystems and components cause unexpected increases in cost. He said the Aeronautical Systems Center is now writing reliability into its contracts and warned that industry must explore thoroughly every action which will produce the most weapons for the least cost.

Sessions winding up the all-day conference explored automation in the shop and office; better materials-handling techniques; simpler, cheaper packaging methods; value analysis of components and materials; and operations analysis.

1..



OVER-ALL CONCEPTION OF TURNKEY POST OFFICE, Providence, R. I., is slated for completion later this year by International Telephone & Telegraph Corp's Intelex, Inc. Mailflo system calls for raw mail in sacks to be conveyed to culler (center, below control tower) where letters are separated from other types of mail and manually carried to facer-canceller machines (left of cullers). Faced and cancelled, letters are now placed in trays to be conveyed to primary sorting machines (extreme left) where letters are separated according to regional, state and local destination. Incoming letters, already cancelled, are conveyed past the primary machines and processed at the secondary sorting area for local (street) destinations. Parcel post automation is located to right.

2..

CULLING MACHINE IS CONSTRUCTED ON THREE LEVELS. Raw mail (parcel post, flats, letter mail and letters too thick or too stiff for acceptance by cancelling machines) is dumped in first reception trough and transported to second and third troughs by vibrating conveyors. Each trough moves back and forth in rocking motion to spread mail for culling as it moves along the conveyor. Mail is fed over a chute from the third trough onto sloping roof surfaces which have cross conveyors underneath spaced so that letter mail is discharged and carried off on a sandwich belt through the mechanical and pneumatic singling devices into the stackers preparatory to cancelling. Flats are discharged onto special belts and transported to cancelling areas.

Mail Goes All-out for Automation

WASHINGTON—The US Post Office is engaged in a $2-billion development project aimed at providing automatic processing of most mail by 1962. Eventually it will affect some 14,000 post offices throughout the country.

Two main tryout areas are now being prepared. One, called "Project Turnkey," will be set up later this year in Providence, RI. The other, "Project Gateway" in Oakland, Calif., will not be ready before 1961.

The Providence installation is being built by International Telephone & Telegraph Corp's Intelex Systems Inc. Much of its equipment is described below. The California installation is expected to house even more advanced equipment, according to its builder, Food Machinery & Chemical Corp.

Both automatic systems will contain units to perform these basic functions:

- Culling raw mail.
- Facing mail in the proper direction.
- Cancelling stamps.
- Sorting cancelled mail according to destination.
- Transporting mail to these various units by an automatic conveyor called "Mailflo."

A culling machine separates raw mail—parcel post, non-letter-size mail and letter-size mail—and channels letters to a machine-processing area. Right now, only letters within a prescribed size, width and thickness can be machine processed.

The Post Office has tried two approaches to mechanical culling. One, a moving-aperture culling machine was found unsuitable. The other, a fixed-aperture culling machine is much simpler in design and has shown more promise. Still another approach being developed is a rotary-drum culler patterned after a British model.

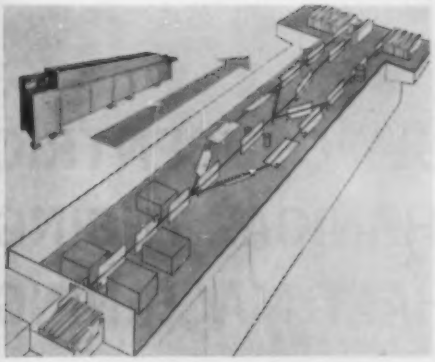
Capacity requirements for the cullers right now range from 30,000 to 6000 letters per hr. Eventually, however, the Post Office expects to buy smaller cullers with rated capacities starting at 15,000 letters per hr for smaller post offices in the country.

Two systems using principle of light reflectance on scanners have been developed for facing letters and cancelling stamps. One, by Emerson Research Laboratories, cancels letters in one pass through the machine; another, by American Machine & Foundry, turns around letters not stamped in the conventional manner, then turn-around mail is passed through machine and cancelled.

A third, developed by Pitney-Bowes Inc, consists of two machines operating in tandem. As the letters stream through, machine's electronic scanners locate positions of the stamps and direct the envelopes to one of four cancelling dies, after which they are stacked automatically.

Three basic approaches are being tested by the Post Office to get machine sorting of letters. The first is the keyboard control method developed by Rabinow Engineering Co. Letters are dropped into 14-letter carriers that channel the mail to

3..



FACER-CANCELLER MACHINE processes first class letter mail and post cards up to 10 in. in length, 5⅝ in. wide and ¼ in. thick at an operating speed of 8 letters per sec, 24,000 per hr. Culled and stacked, letters are fed, one by one, by an automatic pull-off device into measuring, positioning and scanning units for location of stamps. Letters without stamps, metered mail, letters with stamps not placed in the upper right-hand corner and off-size letters are deflected to a seperate stacker where letters requiring special handling are stacked. Letters with normally positioned stamps are faced properly (stamp down) for cancellation. More recently designed . . . eliminate manual facing.

any one of 300 destinations. Destination boxes are manually emptied periodically and the mail is machine wrapped, tied and placed on a conveyor for delivery to the sacking area.

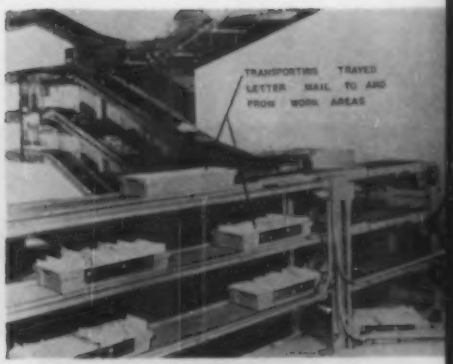
Burroughs Corp took a keyboard concept and built 10 production models. These sorters are built with 300 destination pockets and 12 keyboards. Each operator is capable of handling 3000 letters per hr giving the system a capacity of 36,000 letters per hr for normal working conditions.

Pitney-Bowes Inc, also working with the Rabinow concept, is attempting to vary the system by sending letters through in a continuous chain rather than grouping letters in trays or carriers. This would reduce size of machines by about 20%. The Stamford firm is also seeking to develop a mechanical method of sweeping the pockets clean periodically, further reducing manual contacts with the mail.

A second approach to mail sorting is a coding system, using the binary-dot principle, developed by the Bureau of Standards. The Post Office has awarded a contract to Rabinow Engineering to build a test coding system that will include equipment for code printing, a memory system and letter sorter. The Post Office is also working on metallic strips for coding letters magnetically. A third approach to letter sorting is an automatic reader that can read both typed and handwritten addresses. Intelligence Machines Corp has developed a transistorized machine that can read and sort mail to 20 destinations. It depends on logic circuits activated by scanning oscillators to differentiate among the various address abbreviations and type sizes.

All of the Post Office's basic keyboard sorting equipment is built in modular form with basic 45-destination pocket units to give the equipment flexibility. For example, it can combine with the other systems—cod-

(CONTINUED ON PAGE 20)



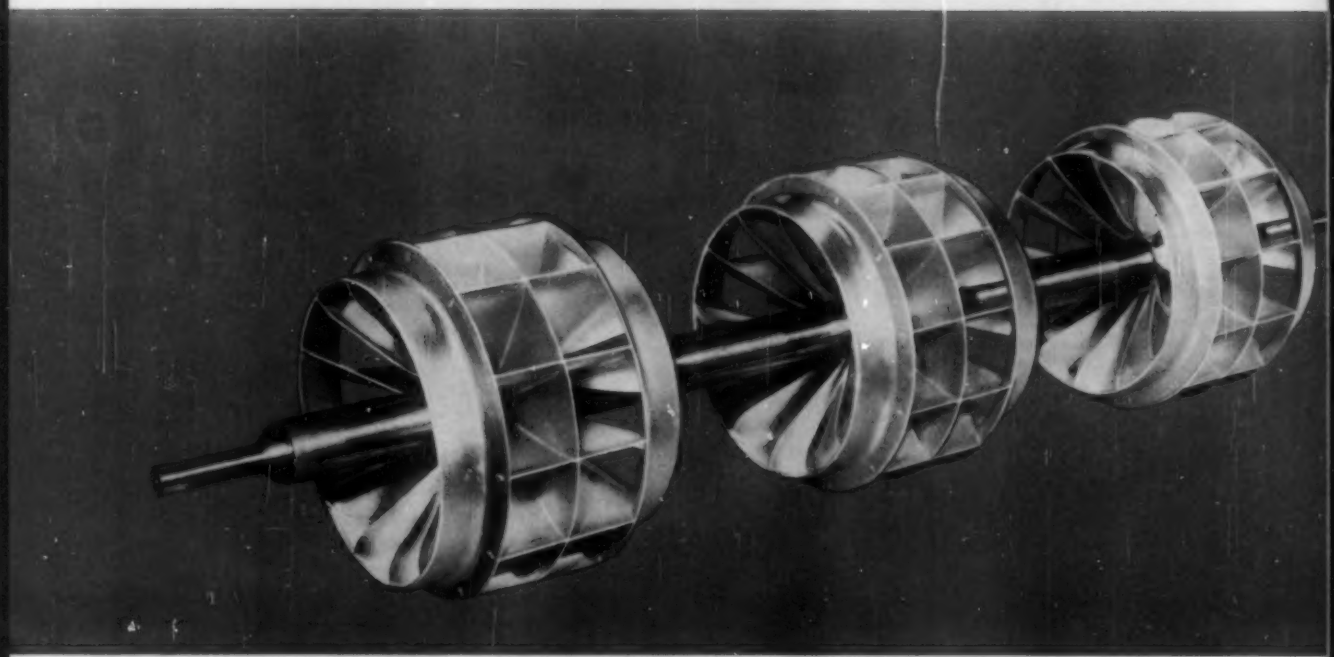
THE MAILFLO CONVEYOR SYSTEM (above and below) handles only trayed mail which is faced for subsequent processing operations. Electronic sensing devices read the codes keyed on the trayed mail for routing to work areas and sorting machines.

4..

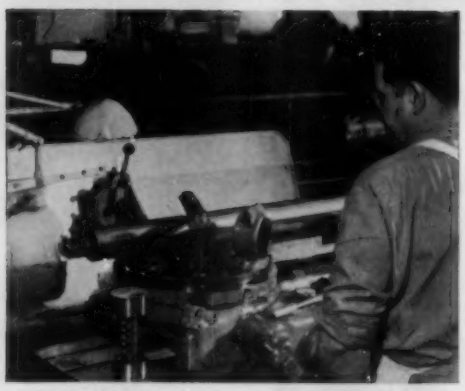
LETTER-SORTING MACHINE (above) is used for primary and secondary distribution. Faced mail is fed to the operator who reads address and keys the code number identified with the destination. Letter passes into a continuous chain carrier which moves it to the proper destination bin (far left) where mail is tied for delivery.

5..

TRULY CONCENTRIC ELECTRUNITE MECHANICAL TUBING ELIMINATES ROTOR SHAFT MACHINING



SCROLL-TYPE BLOWERS up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Careful balance and uniformity of the tubing is required for high operating efficiency.



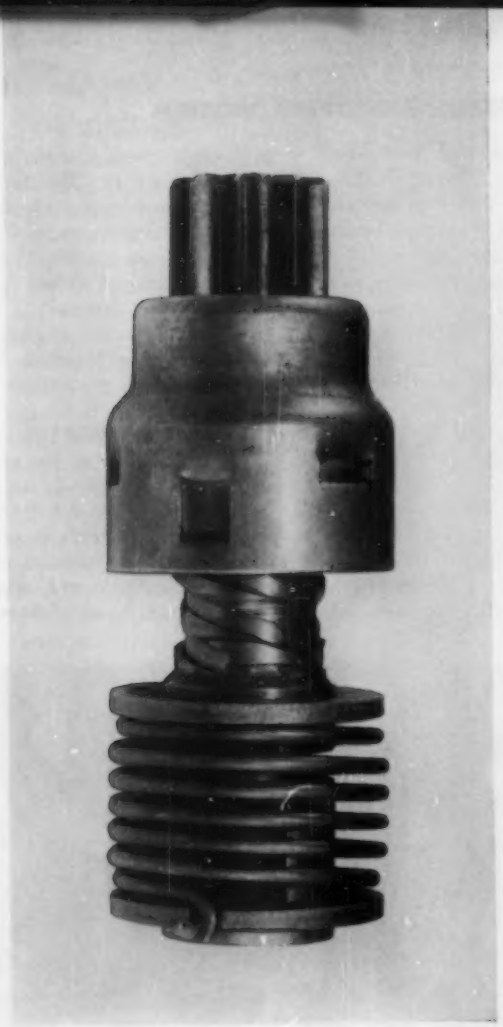
DUE TO THE UNIFORM CONCENTRICITY of Republic ELECTRUNITE Mechanical Tubing, no machining is required in producing air conditioning rotor shafts at Buffalo Forge Company. Rotor shafts are bored at each end and plug inserted for the bearing. Because of the uniformity of ELECTRUNITE, only .015 of the stock is removed before the plug is pressed into the tubing ends.

Buffalo Forge Company, Buffalo, New York, saves valuable machining time by using Republic ELECTRUNITE® Mechanical Tubing in manufacturing air conditioning and ventilating units. ELECTRUNITE in sizes of 3″ to 3¼″ O.D., 8-gage, is used as shafting for the rotors of the blower system.

Scroll-type blowers up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Small shafting will turn at 2,300 rpm. True concentricity of ELECTRUNITE is vital to high operating efficiency of these units due to the careful balance required in relation to the high rpm and weight involved.

Republic ELECTRUNITE Tubing, carbon or stainless, may solve your particular production or cost problems, too. Call your Republic representative, or write direct.

CIRCLE 18 ON READER SERVICE CARD



2.

1.

1. FIVE REPUBLIC METAL POWDERS give you broad spectrum coverage. Republic's wide range of iron and alloy powders cover all known physical property requirements of metal part fabricators. Send for booklet, ADV. 1014 for complete technical information on Types G, N, S, and Type MS. Information on Type HS6460 is contained in booklet, ADV. 1028. Write today.

2. REPUBLIC COLD DRAWN ALLOY STEEL is used by a leading manufacturer for one of the most critical components in their automobile starter drive assemblies—the drive pinion. Use of Republic Cold Drawn Alloy provides the necessary strength and toughness to withstand severe torque, impact, and prolonged wear. Write for additional information.

3. REPUBLIC NYLOK® FASTENERS provide secure holding power where it's needed most in the Twin Power Riding Mowers produced by Roberton Manufacturing Company, Chicago. A special nylon insert assures positive locking, maximum holding power—even under severe vibration. The insert in NYLON fasteners is unaffected by age or cold, has high resistance to heat. Send coupon for additional data.

3.

REPUBLIC STEEL

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World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
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1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send additional information on the following products:

- ☐ Republic ELECTRUNITE Tubing
  - ☐ Carbon ☐ Stainless
- ☐ Republic NYLOK Fasteners
- ☐ Alloy Steels
- ☐ ADV. Booklet 1014
- ☐ ADV. Booklet 1028

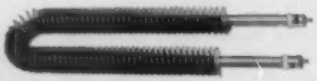
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

STRAIGHT
or
FORMED...



VULCAN FINNED HEATERS

Both Vulcan Finned Strip and Tubular Heaters are available in a wide range of straight lengths. In addition, Finned Tubular Heaters may be formed in a variety of hairpin bends.

Vulcan Finned Heaters provide *six times more effective heat transfer surface* than conventional elements. This makes them ideal for use in blower type electric unit heaters; duct heating; unit convection heating; as oven or space heaters in dryers, pump rooms, etc.; baseboard room heaters — and many other applications.

Write for catalog describing standard sizes, wattage and voltage ratings, sheath metals, terminal construction, and prices.

VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

THE ENGINEERING WEEK

(continued from page 17)

ing and automatic reading. Also, it allows the Post Office to increase or decrease capacity at branches equipped with the machinery. The basic element of the Mailflo system is an endless conveyor that receives sacked mail at the loading dock, then transports it to the various processing stations. Present equipment can move twenty 600-letter trays a minute into the primary distribution area for processing—basic requirement for Mailflo: move mail at a speed that will permit processing within 30 minutes after entering post office. System is now being redesigned to carry mail from machine to machine once the mechanized sorters go into operation.

Though pleased with results up to now, the Post Office is still considering more improvements. Burroughs and several engineering firms in Canada have developed check-sorting equipment which may prove valuable to postal processing. The Post Office's research and engineering section, directed by Wade S. Plummer, will continue intensive research within its own laboratories.

Evidence that Post Office R & D has come of age is the spectacular climb in research funds appropriated by Congress. The $11.4 million allotted for fiscal 1960 is more than double the 1959 figure. And Plummer expects this figure will continue to rise sharply in the next few years. ■

NEW HYDRAULIC SINGLE-STICK CRAWLER-TRACTOR CONTROL, developed by John Deere Inc engineers, is equipped with new master control which activates hydraulics to perform clutching, braking, steering and shifting for forward and reverse travel. "Pilot-touch" eliminates two conventional control levers, permitting operator to select with one hand speed of travel and then move control stick, leaving other hand free to control loaders, bulldozers.

Czechs, Soviets Swap Technology

VIENNA — The Soviet Union and Czechslovakia are reportedly exchanging technical assistance. Dispatches from the two countries indicate the USSR has sent Czechslovakia 163 designs for capital construction; 180 complete sets of blueprints for producing machines and installations; and 315 technical descriptions of production processes as well as thousands of blueprints for individual installations and hundreds of research reports. In return Czechslovakia has sent 108 designs for capital construction and 453 blueprints for building machines and installations to Russia.

Technical personnel exchanges and cooperation between research labs is also reported. Two-way exchange of technical specialists is said to involve about 4000 from each country a year. And more than 30 scientific workers from the Czech academy of science visited the Soviet counterpart last year to coordinate research activities. On the level of research institutes and design bureaus, programs of mutual assistance now involve 167 institutes in the USSR and 140 in Czechslovakia. They have been working together since 1955. ■

Ceramic Research Uncovers Future Uses

DAYTON, OHIO—The promise of ceramic materials is continuing to shape the course of inquiry at the Aeronautical Research Labs of Wright-Patterson Air Force base. At present, research is concentrating on three areas: zirconia and systems of zirconia with metal oxides and refractory metals; boron-silicon-oxygen systems; and physical properties of ceramic materials with emphasis on internal friction, dielectric loss, electric resistivity and Hall coefficients.

Zirconia, the ARDC researchers have found, is suitable in crucibles for melting reactive metals if the ceramic is first modified with 10-15% (by weight) of the reactive material being melted. Such metals as titanium, zirconium and chromium have been successfully treated without contamination from the crucibles. Modified zirconia may eventually find further application in investment molding and

(CONTINUED ON PAGE 24)

DRAFTING TRENDS

Drafting Templates are a valuable tool to faster drafting. They are available in an almost endless variety.

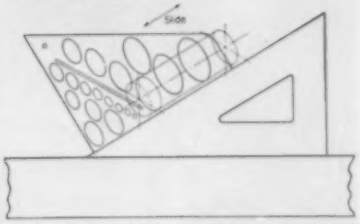
Specialized drafting templates speed drawing time

Always a handy tool, drafting templates are becoming increasingly in use to simplify everyday drawing techniques. Now vinyl plastics are used in the manufacture of the majority of templates. But the thickness, color and finish vary in almost endless profusion. Glare-saving colors, such as green and amber, are usual, both in clear and matte finishes. However, the white and clear plastics still are popular. The thicknesses vary with the different types of available templates from .020 gauge through .070 gauge.

Specialized template applications

A list showing the growing application for templates includes templates for: Electronic Symbols, Electrical Wiring, Landscaping, Screw Heads, House Plans, Nuts and Bolts, Screw Threads, Tooling, Windows, Plumbing, Mathematical Symbols, Map Planning, and many "all-purpose" templates for circles, ellipses, triangles, and other shapes.

Isometric ellipse template is a big timesaver



An isometric ellipse template may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.

A selection of 52 popular templates is illustrated and described in a special six page brochure, "Drafting Templates" recently published by Frederick Post Company. *For your copy, write Frederick Post Company, 3642 N. Avondale Ave., Chicago, Illinois.*

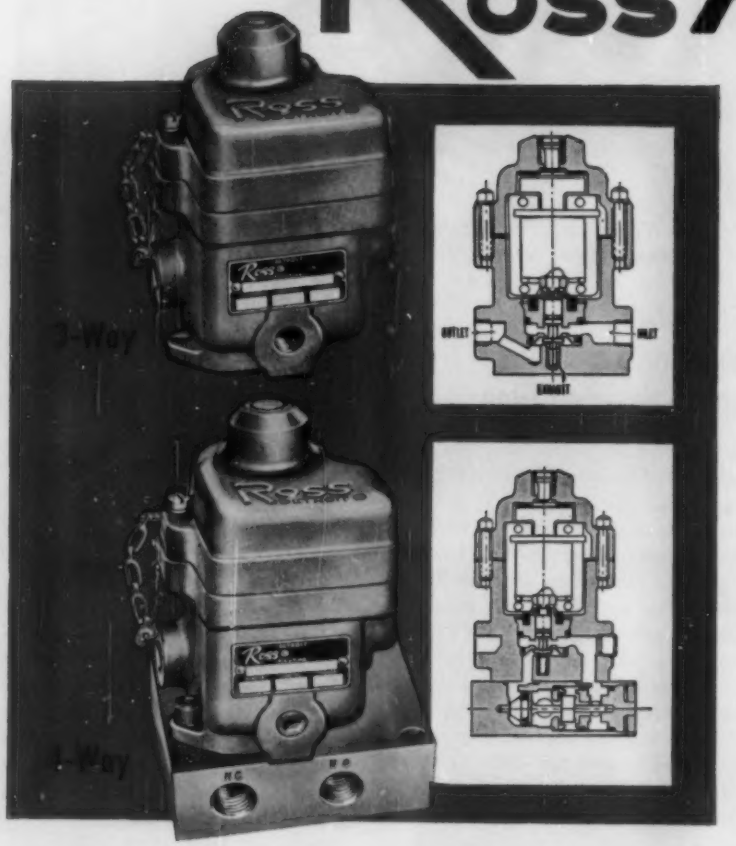
POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Announcing

a new and better solenoid valve in the $\frac{1}{8}$" and $\frac{1}{4}$" size range

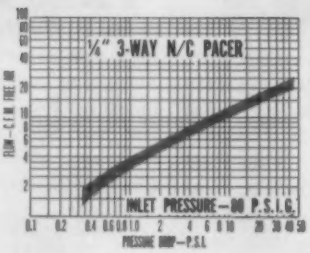
Ross *PACER*



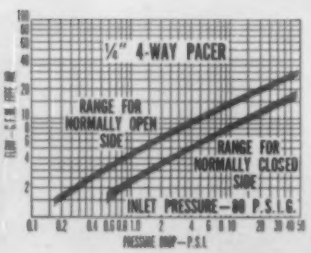
More life
More speed
More capacity
More value

Now you can have about three times more flow capacity-to-solenoid size than in most competitive valves. Needs just 7 watts of power yet minimum internal orifice size is full $\frac{1}{32}$". The PACER has short poppet travel, will cycle at better than 1000 cpm and meets JIC specifications. Lightweight, cast aluminum body means 3-way weighs just 20 ounces, 4-way just 28. Dust tight, liquid tight, can be manually actuated, has captive cover, is inoperative with cover removed, has integral wiring space. Why not test a PACER in your own circuit, just $18 for a 3-way, $26 for a PACER 4-way. Call your Ross representative or write for Bulletin 319.

Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



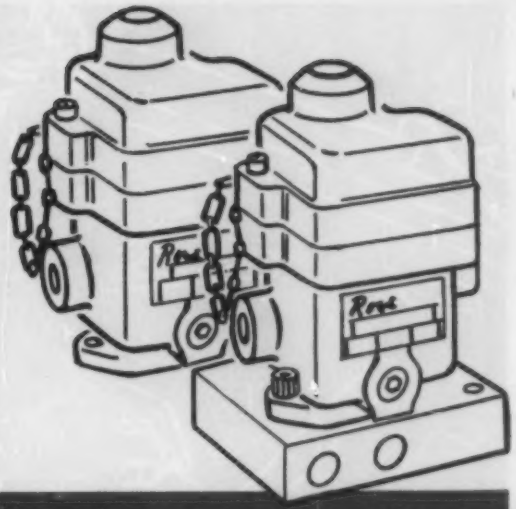
STAY AHEAD
MODERNIZE

ROSS OPERATING VALVE COMPANY

114 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

The Ross PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the ⅛" and ¼" size range that gives a full ⅜" flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate *any* valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.

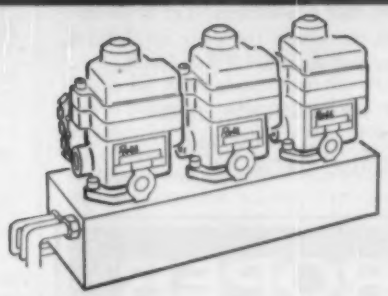


As well as being a complete new valve

...PACER is also a new pilot section in the Ross Skyline valve series...

COMPLETE PACER VALVES	PIPE SIZES ⅛"	¼"	⅜"	½"	¾"	1"	1¼"
STRAIGHTWAY, N/C	√	√					
3-WAY, N/C	√	√					
4-WAY	√	√					
SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)							
STRAIGHTWAY, N/C		√	√	√	√	√	√
STRAIGHTWAY, N/O		√	√	√	√	√	√
3-WAY, N/C INLINE MT.		√	√	√	√	√	√
3-WAY N/O, INLINE MT.		√	√	√	√	√	√
3-WAY, N/C, BASE MT.		√	√	√	√	√	√
3-WAY, N/O, BASE MT.		√	√	√	√	√	√
4-WAY, INLINE MT.		√	√	√	√		
4-WAY, BASE MT.		√	√	√	√	√	√
4-WAY, 5-PORT		√	√	√	√		

New PACER manifolds to save piping and wiring



Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.

STAY AHEAD MODERNIZE

ROSS OPERATING VALVE COMPANY

114 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

CIRCLE 23 ON READER SERVICE CARD

Helical Pumping Gears
•
4-Port Design
•
Mechanical Shaft Seals
•
Replaceable Bearings
•
Hardened Shafts
•
Packed Box Construction
•
Cast Alloy Housings

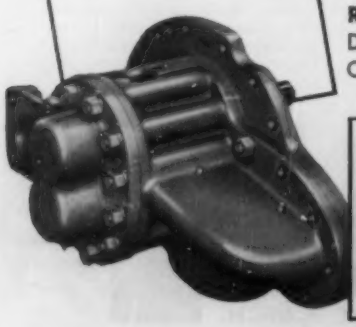
Name your "specs"

Custom Pumps for your design

Consult Roper about the special pumps needed for your projects. Our long experience in designing and building pumps for leading original equipment manufacturers makes possible savings in development time and unit cost.

Whether your problem is high pressure, low pressure, capacity, size or weight—Roper has solved requirements like these for many customers. Let us go to work on the pump for your application. Write or call us today.

ROPER HYDRAULICS, INC.
DEPT. 391 — P.O. BOX 269
COMMERCE, GEORGIA



ROPER
ROTARY PUMPS

(CONTINUED FROM PAGE 21)

casting of these reactive materials.

Originally, boron-silicon-oxygen systems were headed for application in aircraft parts that would contact the boron oxide which forms with combustion of high-energy fuels. ARDC refuses to discuss alternative applications should the on-again, off-again, high-energy fuel program die.

Closely related research on slip-casting of metals and cermets is also underway. Slip-casting is especially suited to production of hollow shapes. In this technique, a colloidal suspension of the material is poured into a porous mold, which is generally made of plaster of paris. As the mold adsorbs water from the suspension, the suspended material is deposited on its surface and assumes its shape.

The slip-cast part is then removed from the mold, dried, fired and sintered. Removal is exceedingly difficult; degree of difficulty is inversely proportional to thickness of the cast part. ARDC has found that a thin film of a solution of sodium alginate on the mold walls will ease extraction. The film acts as a tenacious porous membrane that also cuts down corrosive attack of the slip on the mold and prevents contamination. ■

Mechanical Problems Delay Reactor Start up

DRESDEN, ILL—Commonwealth Edison's big Dresden atomic powerplant, the first large-scale boiling-water reactor, is off schedule. Not through any strange nuclear quirks, but because of failure in its control-rod drive mechanism. The rods, special alloys that adsorb neutrons, are used to control; and, in emergencies, to halt nuclear chain reactions. They are lowered slowly to adjust the operating level, are dropped rapidly for emergency shutdowns.

At the Dresden plant the problems have ranged from separation of rod and drive and failure of seals to inadequate buffering of the rods at the travel stops and overloading of shear pins.

Still, GE's Atomic Power Equipment Dept, which designed and built the reactor for CE—Chicago's big Utility company—claims "this does not indicate any shortcoming in the control drive design."

GE goes on; "the shear-pin problem

can be solved by reduction of stress and replacement of damaged pins. We anticipated having purely mechanical problems of this type, and we should expect to encounter more of them before our 'shakedown' tests are completed. Such problems are normal to any plant startup." GE engineers are modifying design of the reactor itself to reduce the high startup loads which damaged the shear pins.

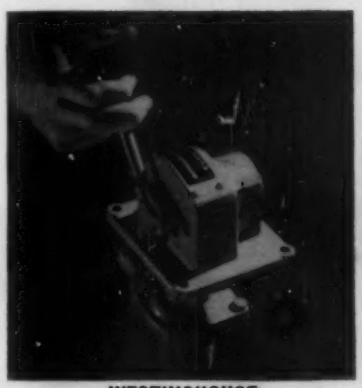
CONGRESS MAY INVESTIGATE

WASHINGTON—Dresden's shake-down problem should be remedied by mid-January, but there may be some hangover resulting from the way publicity on the shutdown was handled. The chief of the Joint Atomic Energy Committee plans to look into the situation when Congress convenes. Sen Clinton Anderson, chairman of the committee isn't happy over news of the shutdown and the fact that it wasn't made available until seven weeks after defects in the powerplant were discovered. ■

Polaris Bird Gets Nest

These double-lined, shockproof shipping containers are designed for air, rail or truck transportation of the submarine-launched weapon. Inside portion of the missile's double container consists of a fiberglass inner liner incorporating electrical heating elements to hold uniform temperature during transit or storage; a 2-in. foam plastic insulating layer; and a tough aluminum alloy skin. Inflated air cushions between the inner and outer containers prevent jostling or vibration in transit. External container is removed when missile is loaded on ship. Designed and constructed at Lockheed, Burbank, the entire container weighs approximately 11 tons.

Typical Control Functions solved by AIR CIRCUITRY



WESTINGHOUSE "H" CONTROLAIR® VALVES

Air control valves are not limited to directional control in Westinghouse Air Brake Company's complete line of Air Circuitry components. Pressure control, in addition to directional control, is obtained with the versatile "H" CONTROLAIR Valves. The position of its operator—lever, pedal, cam or knob—determines the air pressure delivered by the valve. Changing operator positions changes delivery pressure.

Precise pressure graduations may be made in one or two outlets to provide exacting remote control of variable force and positioning applications. Besides those functions illustrated a wide variety of pressure and directional control combinations is available. For details, ask for Catalog D4-65.00.

Applications for "H" CONTROLAIR Valves are limitless. They operate:

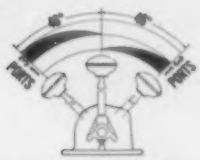
Throttles	Rolling Mills	Marine Propulsion Engines
Clutches	Presses	Construction Equipment
Brakes	Shears	Oil Drilling Rigs
Clamps	Conveyors	Production Tools
Gates	Dredges	Cranes and Shovels

and many other kinds of equipment and machines. In fact, "H" CONTROLAIR Valves are used wherever it is necessary, or preferable, to have instant and convenient control of the flow of air into a pneumatic circuit and of the pressure build up of air in that circuit.

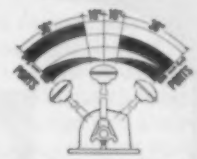
What is AIR CIRCUITRY?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

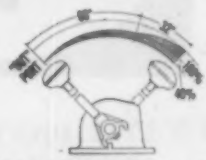
1. SINGLE LINE PRESSURE CONTROL—Pressure regulation in a single line is obtained through the H-2 CONTROLAIR Valve. This lever-operated, 3-way, pressure regulating valve increases, decreases or maintains outlet pressure according to its lever position. Several types of lever return or holding functions are available.



2. DIRECTIONAL PRESSURE CONTROL—The HC-2 CONTROLAIR Valve provides pressure graduation to either of two outlets. This lever-operated 4-way, pressure regulating directional valve consists of two 3-way directional valves and a 3-way pressure regulating portion. Lever movement either side of its "Neutral" position selects the outlet to be activated. Further lever movement in the same direction controls the pressure of the air delivered to that line.



3. DIRECTIONAL AND PRESSURE CONTROL—Pressure regulation plus full supply pressure directional control is possible with the HD-2 CONTROLAIR Valve. This lever-operated valve consists of two 3-way directional valves and a 3-way pressure regulating position. Each unit has its own outlet. Lever movement either side of "Neutral" provides full inlet pressure to a chosen outlet plus graduated pressure to a third outlet.

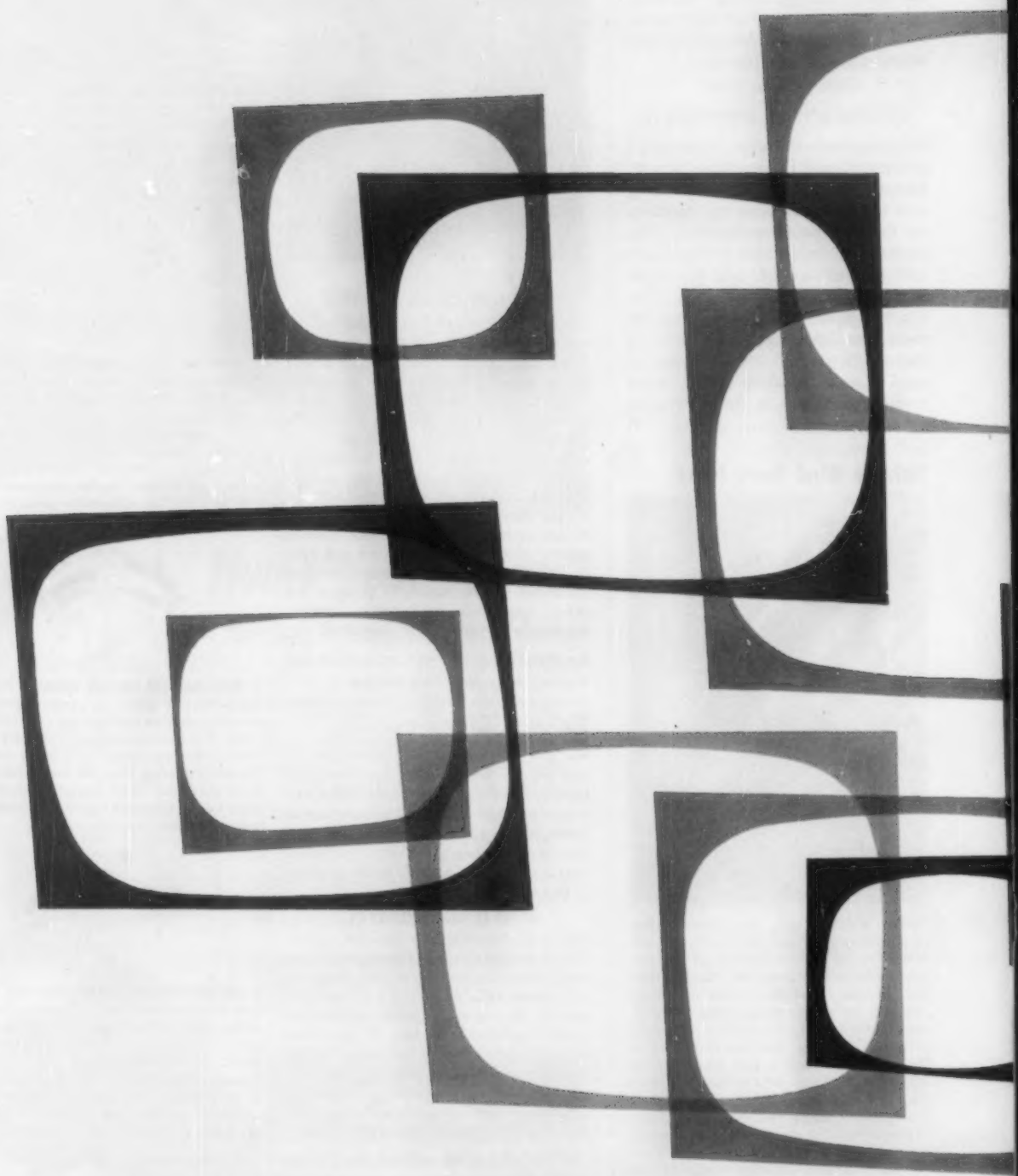


4. TWO RATE PRESSURE CONTROL—The first 60° of lever movement from the "Off" position provides an increase in delivery pressure from 0 to 40% of maximum value in the H-2-E type CONTROLAIR Valve. The remaining 32° of lever movement increases from 40% to its maximum value. Used in applications that require closer pressure adjustment at the low end of the delivery pressure range than at the high pressure end of the range.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Better products through better methods and steels

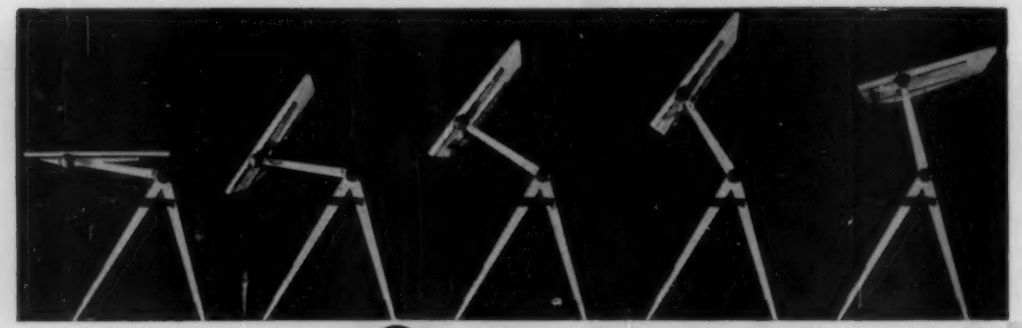
How zinc-coated steels improve the profit picture in TV-set manufacturing

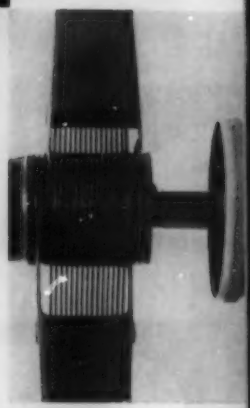
Solid savings in TV manufacturing often come in small ways. Take the case of the TV masks once made of cold-rolled steel and painted on both sides to stave off corrosion. When the switch was made to Weirzin electrolytic zinc-coated steel, protective painting bowed out. Because Weirzin's uniform, corrosion-resistant surface is impervious to heat and humidity, the mask's interior is left as is. The exterior is painted purely for decoration—and with Grade A results since Weirzin comes chemically treated to provide a superior bonding surface for paint. Weirzin electrolytic zinc-coated steel is but one of many fine steels produced by Weirton Steel Company—improving products, methods *and* profits throughout industry.

WEIRTON STEEL
Weirton, West Virginia

CIRCLE 27 ON READER SERVICE CARD

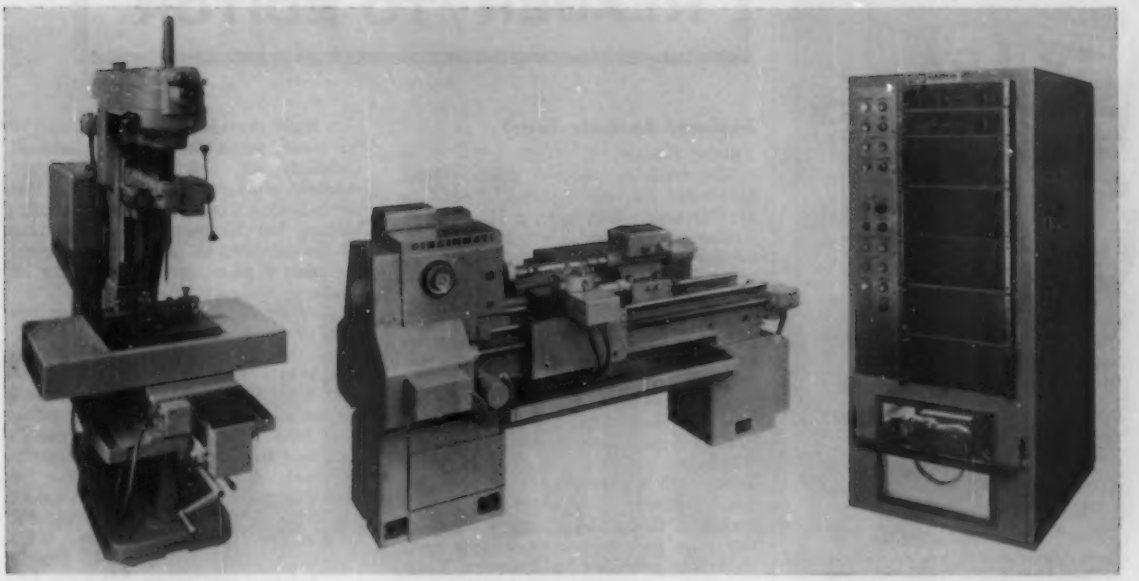
TRENDS IN APPEARANCE DESIGN





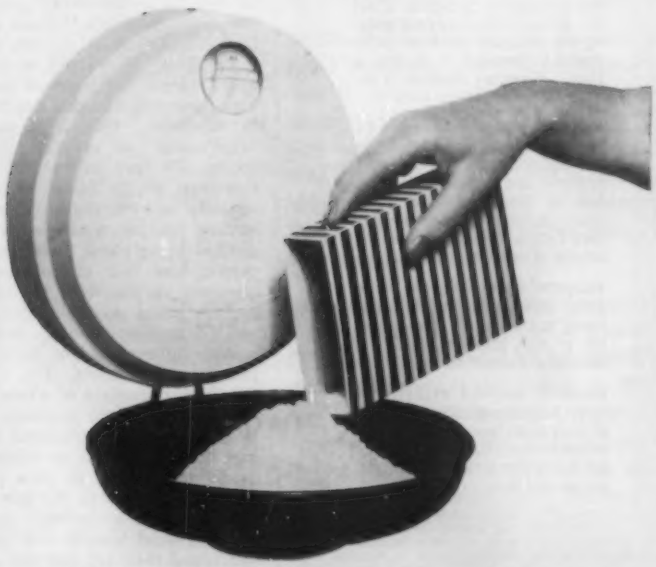
LIGHTNESS AND GRACE of this drawing table-desk bespeak its versatility. Board height can be adjusted as well as angle, from 30 to 45 in. from floor. Rigid locking joint consists of 15 steel leaves pinned together in box-type pressed-steel legs, which mesh with similar leaves secured to board's support arms. One of four plastic feet is adjustable to compensate for uneven floor. Designed by Willy Rietveld for n. v. De Cirkel of Zwanenburg, Holland.

THIS 10-TON TRACTOR, characterized by simple monolithic lines, is powered by a 218-hp diesel, and has worked as much as 19 acres an hour at a speed of 5 to 6 mph while carrying a fully equipped 31-ft-wide tool carrier. Tractor is shown, in inset, picking up biggest plow ever made—weight, 2½ tons. Articulation of front and rear wheel units allows 17½-ft turn radius. Made by Deere & Co, Moline, Ill.



AT LEAST ONE REASON for the neatness of this "square-look" numerically controlled lathe (center) is the lack of manual controls. Housing for input and feedback circuitry have been well integrated into tailstock, tool carriage, headstock. While control console is similarly clean-lined, no serious attempt aside from color was apparently made to link these complementary units through other appearance characteristics—probably because lathe is same basic model originally styled for manual control. This also applies to drill press (left), also numerically controlled. Here, little or no attempt at integrating "black boxes" is indicated and rounded lines indicate design originated in pre-"square-look" period. By Cincinnati Lathe & Tool Co.

VACUUM CLEANER for hotels, stores, schools, hospitals slides along floor on metal skids, stands on end and can also be fitted with brackets for permanent wall mounting, temporary suspension from pole or column, or carrying on back. However, exposed position of switch when carried may permit accidental actuation—and operator may have difficulty reaching it. Designed by Joseph Carreiro Associates, Philadelphia, for Black & Decker Co.



UNOBTRUSIVE KITCHEN scale (10-lb capacity) mounts on kitchen wall so that it can be located where needed without taking up working space. Removable (for emptying, washing) outer cover swings down to serve as weighing pan. Both pan and housing are molded plastic. Made by Jupiter Gmbh, West Germany, available in US from Italian Imports Co, 2251 Murray Hill Rd, Cleveland.

The INSIDE INFORMATION

Here's literature prepared expressly for design men to simplify selection and application of the most appropriate molded packings for better product designs. These bulletins are packed with helpful charts, dimensions, diagrams, application drawings, recommendations and hints to save material and machining costs. They're yours for the asking—can help considerably in your quest for stepped-up product efficiency.

To help you keep abreast of up-to-the moment developments, trends, changes . . . write for your complimentary Palmetto Kit for Design Engineers.

ABOUT PALMETTO® MOLDED PACKINGS

The entire line is engineered for efficient utilization of space, material and cost. If you design-in molded packings for fluid powered equipment—you should specify and buy the proven performance Palmetto line.

PALMETTO G-T® RING — Effectively seals, without extrusion, at temperatures from —70 F to +600 F, and at pressures as high as 10,000 psi. Unique T-shape prevents wedging into clearances, pinch-offs under motion or pressure, or twisting in place. Absolutely resistant to destructive deformation.

PALMETTO PYRAMID® — An advanced form of V-rings, offered in two distinctive designs for broad hydraulic and pneumatic service. Sets of shallow Pyramid serve where packing space is limited; deep Pyramid sets are used where unusual sturdiness is necessary.

PALMETTO U-RING—Rugged, deep design increases stability, eliminates rolling in the groove. Excellent in low or high pressure cylinders—nominal or oversize bores.

PALMETTO KUP—An exceptional piston packing available in a variety of fabrications to seal the standard, or new synthetic fluids. More resistant to heat than leather . . . will not dry out and leak.

Whatever your sealing requirements—including diaphragms, Viton® molded parts, and other molded shapes — Palmetto engineers will work with you. Write today for your Palmetto Kit for Design Engineers — Feel free to call on Palmetto Design Service for assistance.

GREENE, TWEED & CO.
NORTH WALES, PA.

READER / TO EDITOR

Engineer Aptitude Tests?

To the Editor:

The tendency of your article, "How Good Are Engineer Aptitude Tests," in the November 30th issue, p 32, although written in the form of a question, seems to also support the so-called personality tests intended to measure objectivity, agreeableness, energy level, social leadership, emotional stability and so on.

In confronting several testing agencies and personnel departments with a question like the one you asked, it does not necessarily mean that their answer is the final and decisive word. These institutions are rather party to one opinion. There are, however, a number of *homo sapiens* still in existence, critical of measuring emotions. Since there is always the danger of taking the printed word at its face value and, even more, looking upon an article published in PRODUCT ENGINEERING as the ultimate in knowledge, it is necessary to warn your readers and possibly caution them regarding any psychology test.

I do not want to raise my voice against a test of aptitude alone. They have proven useful in distinguishing capabilities. One has, however, to watch for aptitude tests mixed with psychological so-called personality tests. What is personality? Is it the way somebody smiles or talks? Psychologists admit it is not. One has to go deeper. But how much deeper? William H Whyte, Jr has given us recently a wonderful cross-section of the North American human race in his book, *The Organization Man*, especially in the chapter, "The Tests of Conformity" which cannot better reveal the facts behind these tests, the fatal step from science to scientism. Using "percentiles" and "coefficients" in evaluating test results should not lead anybody to the belief that these are the factors to translate uncertainty into certainty. These tests are nothing else but a correlation of the individual being tested to certain groups of people, how they reacted and answered questions in the test. There is not a single so-called personality test which can and will measure emotion. In spite of our hammering environment with all its impact from advertising, TV, schools and the "higher standard of education," there are still people with emotions and ideals. Who else but the professional man should start to put an end to scientism. We should stop trying to press people into an imaginary form of life only to comply with rules and uniformity. An executive must surround himself with persons who understand their job and the people they have to deal with. If a personnel manager has no foundation in humanism and not enough experience of life, in other words, has to rely on a battery of personality tests in order to judge a person, he is in the wrong place.

In the hypothetical event that these tests really should reveal the innermost of one's self, would they then be justified? Definitely not. Mr Whyte has found excellent phrases when he reasoned that the individual's innermost self is nobody's business but his own. A company can ask the individual for top-class work against the salary it pays. It can not ask for his psyche as well.

Since we certainly will have these tests with us for a while, what can the individual do? He can cheat and, agreeing with Whyte, he must cheat. Let him respect himself. It might sound rather hard but let us have hard words now rather than hard facts later when everybody's mind and thinking is ruled by uniformity. To reach uniformity will not take too long if we go on travelling at the pace we do, living in superlatives, glorifying the mass at the expense of creativity.

—R STEIDL
Special Construction Machines Ltd
Toronto

COMING EVENTS

JANUARY

11-13 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, American Society of Quality Control, Electrical Industries Association, 6th National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C.

11-15 . . . . Society of Automotive Engineers, Annual Meeting, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

12-15 . . . . Society of Plastics Engineers, 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago.

15 . . . . Malleable Founders Society, Semi-Annual Meeting, Hotel Sheraton-Cleveland, Cleveland, Ohio.

18-21 . . . . American Astronautical Society, 6th Annual Meeting, Statler-Hilton Hotel, New York.

25-28 . . . . Plant Maintenance & Engineering Show, Convention Hall, Philadelphia, Penna.

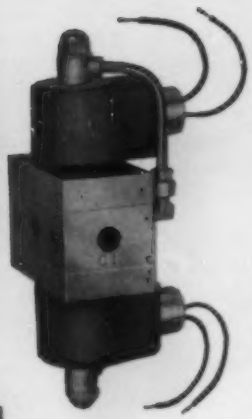
25-28 . . . . Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York.

26-27 . . . . Society of Vacuum Coaters, 3rd Annual Meeting, Hotel Biltmore, New York.

31-Feb 5 . . . . American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York.

New 3 Position,
4 Way Solenoid Valves
Feature Dead Tight
(Poppet Type) Seating

ELIMINATE PISTON DRIFT



ASCO's new 3 position 4 way (Bulletin 8347) permits no leakage on air or liquids, assures precision positioning and positive locking of cylinder piston. Graduated (inching) or full stroke of piston may be obtained by regulating the length of time each solenoid is energized. When both solenoids are de-energized, the valve assumes a center position. All orifices are blocked, locking the cylinder piston at any point in the stroke.

Simple valve design (only moving parts are 2 solenoids and 4 diaphragms) and overall rugged construction provide millions of trouble free operations. These new valves can be mounted in any position, are available in ¼" and ⅜" pipe sizes, handle air, water and oil at pressures to 250 p.s.i. Bulletin 8347 Valves are stocked for immediate delivery.

ASCO Solenoid Valves are stocked at the Florham Park Factory, and at warehouses in Chicago and Los Angeles. **WRITE** for catalog literature on the new Bulletin 8347, and for the new ASCO Stock List and Selection Guide (Publication 506) listing the world's largest stock of solenoid valves for immediate delivery.

ASCO Valves

Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 31 ON READER SERVICE CARD

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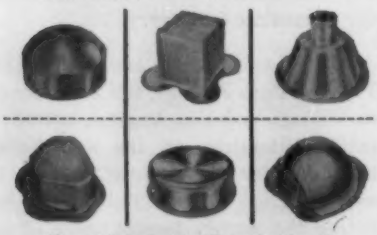
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

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WHY DON'T THEY R&D..?

The following problems have been encountered by the Armed Forces.

. . . a nondestructive means for inspecting hidden welds. Such welds are often located behind thick plates or large masses of metal where flaws cannot be detected with sufficient sensitivity by X-ray or supersonic methods. One application: inspecting a welded, leaktight closure in munitions filled with toxic chemicals.

Also needed is a means for checking effectiveness of a weld while the weld section is still hot (around 1300 F). In particular, this equipment is needed for an induction welding machine that joins two pieces of pipe, 6 to 16 in. OD with wall thickness varying from $\frac{1}{16}$ to $\frac{1}{2}$ in. Inspection time for this application must not exceed 3 sec and defective areas should be identified visibly. Equipment must be compact, mobile, and require no shielding to protect nearby operating personnel.

. . . a high-efficiency jet air ejector. Even at the low efficiencies reached so far —20.6% max—jet compressors, because of their simplicity, have found wide application in steam-jet refrigeration, air ejectors, mine and tunnel ventilation, mercury diffusion pumps, dehydration. Higher efficiency would make jet compressors practical for refrigerators, heat pumps and fluid circulators. But before this can be done, someone must determine the extent to which efficiency limitations are fundamental, and what advantages can be gained by changing operating conditions and design.

. . . a high-speed camera in which image is focused on film $2\frac{1}{4}$ x $2\frac{1}{4}$-in. or larger to give clearer large-frame images than are available with present high-speed cameras. Must be capable of speeds up to 1000 frames/sec with 5 x 5-in. format. Must have low vibration and good resolution across the entire field.

. . . a calorimeter with fast response for measuring moisture content of steam entering a turbine. During rapid load transients, saturated steam generated by a pressurized-water or boiling-water reactor sometimes enters the turbine with too much moisture. To keep turbine-blade erosion and maintenance at minimum, most turbine manufacturers specify that steam entering throttle shall not exceed 0.25% moisture. Steam purifiers will remove excess moisture if activated, but common steam calorimeters do not react fast enough to protect turbine blades. Perhaps an electronic calorimeter would solve the problem.

. . . a method or device for activating a spare electronic component when original component fails. Reliability of tubes, amplifiers, and other components could be improved if they had multiple self-activating channels or spare self-activating components. Should be simple, small, and dependable.

If you think you have a solution for any of these problems—or if you wish additional information—get in touch with National Inventors Council, US Department of Commerce, Washington 25, DC.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland–Absolute Alignment

10 Piston Rod, Extra Strong–Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

CIRCLE 33 ON READER SERVICE CARD

CIRCLE 34 ON READER SERVICE CARD→

CLARE
NEW...
Clare printed circuit relays,
custom built to **your** design,
offer sensational savings
in space, weight, and cost
for modern data processing
and other high speed
switching devices

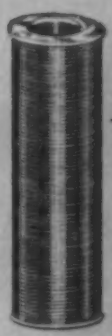
Relay mounted on **your** circuit board

This outstanding relay assembly permits single or multiple installation of CLARE mercury-wetted contact relays in the small space of a printed circuit board. It plugs into a console in the same manner as the logic circuit it serves.

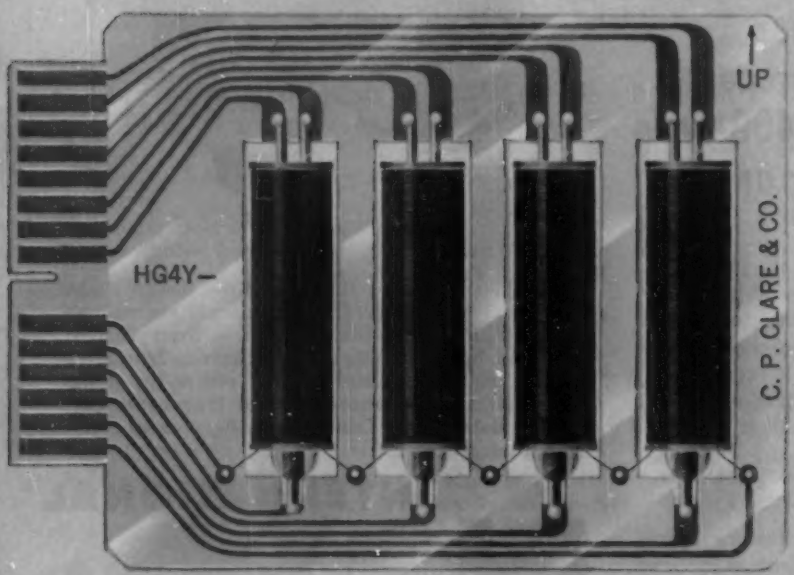
It brings to designers of data processing and data logging equipment all the proved advantages of CLARE mercury-wetted contact relays in the smallest possible space. Individual switch capsules and coils are affixed to the printed circuit board and sealed from dust, moisture and tampering by "Skin-Pack," a tough vinyl coating.

Let us show you how we would adapt your board to include either the standard HG relay or the ultra-high speed HGS . . . as well as other selected components.

CLARE mercury-wetted contact switch hermetically sealed in high-pressure hydrogen atmosphere. Life expectancy over a billion operations.



Each capsule is surrounded by individual coil which is custom-wound to suit the operating characteristics of the customer's application. *For full information on CLARE HG printed-circuit relays send for Bulletin CPC-4.*



Typical assembly

Send us your printed circuit board

Discover how you can save time, space and money . . . enhance the performance of your high-speed equipment . . . with CLARE printed circuit relays. Contact your nearby CLARE Representative, or address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario.

CLARE RELAYS

FIRST in the industrial field

Major airlines around the world . . . . .

prefer **HOBART** aircraft energizers powered by **INTERNATIONAL®**

Report from Roger Frantz, Design Engineer, Hobart-Motor Generator Corp.

"Here's why we use IH power in our all new self-propelled and portable 400-cycle ground power units...

UV-549 V-8 engine 257 max. hp @ 3,400 rpm Gasoline, LP Gas or Natural Gas.

"**Wide range of power sizes** available in the International line fits in with Hobart plans to offer the customer a wide selection of models to choose from.

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When your products advance to the design stage, check into the complete International engine line —14 carbureted models, 10 diesels, from 16.8 to 385 max. hp. You'll like the one common feature of all 24 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

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IH ENGINES

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A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

CIRCLE 36 ON READER SERVICE CARD

PRODUCT ENGINEERING HORIZONS

January 11, 1960

That Third "R"

Calvin Coolidge was supposed to typify the down-East tradition of taciturn men. When his wife asked him what the sermon was about after he'd gone solo to church, he said, "Sin." After a silent morning spent visiting a famed Florida arboretum, he entered the domed main hall, which featured a giant tropical tree. His comment: "Bananas."

The West had a similar tradition of strong, silent men, which a well-known speaker once explained with: "They don't take baths, and they have nothing to say." In any case, the tradition of silence is perhaps the greatest handicap that has ever been placed upon the modern American, East or West. Present-day addiction to bridge and TV have perpetuated it—nobody talks any more except about trivialities. As a result, when an American is called upon to speak in public, he goes into mild panic.

Engineers who have faced this problem have joined toastmaster clubs, taken public-speaking courses, or tried to learn how to influence people, meanwhile damning their alma maters for failing to teach them oral reporting. Somehow, they feel that speaking in public is like parachute jumping—something that must be done right the first time—or like well drilling, which shares with parachute jumping the distinction of being a craft in which one starts at the top.

Nothing could be further from the truth. You learn to speak in public by speaking in public; there is no short road. That doesn't mean you begin with an oration; orators are out of fashion these days, even in politics. You begin by talking to individuals, progress to small groups, then to large. There is no basic difference between talking to one person and to an army—you just think so.

Let's assume you've been tipped off that your company is about to suspend operations. You start to tell your sidekick. Men begin to gather, and you have to repeat. Eventually, there are so many men around that you're asked to get up on a chair. You raise your voice to reach them all; you expand your gestures. You're making a speech! Now, when did you begin—when the crowd swelled to three, when you got up on the chair, or when you raised your voice? The real answer is, of course, when you started to talk to the first man.

"Oh, no!" you'll insist, "A speech is different; people aren't talking back!" Aren't they? You're still talking to individuals, whether there's one or a crowd. And you've got to get your story across, got to get a reaction, or there's no communication. You can't talk Chinese or whisper. You've got to dial the audience's number before you give them the message.

"There's a hooker!" you'll say. "Somebody is forever wanting me to deliver a paper on my specialty, and it's too involved to put into simple words. I've got to use a special language, with equations." Well, perhaps you do, but how do you explain your job or your discovery to your wife? You can't use the special words then. If you're excited about it, interested in it, you can find words and gestures to explain it to a schoolboy.

"This is, perhaps, the key: to be interested in, even excited about, what you're going to say. Beyond that, all anyone can give you about oral reporting, speech making, or orating is some general pointers. That we're going to attempt in seven one-page lessons, starting this week on page 38.

This series might be called the third "R". We began with a six-page series on rapid reading a year ago, followed with an even-more-popular eight-article series on report writing last fall. For the engineer, the third "R" in the old series of "readin', 'ritin' and 'rithmetic" might well be changed to "reportin'" (or "rhetoric"—to use an old word) since we developed computers. For good measure, we've included what we can about chairing a panel or a meeting. We expect to be repaid in better engineering reports and technical meetings.

We'll be hearing you!

R. Langenman

7 steps to better oral reporting

E J TANGERMAN,
editor

* step 1:
From ideas to outline
step 2:
How to organize a talk
step 3:
Now you need notes
step 4:
Hints on delivery
step 5:
Platform manners
step 6:
Chairing committee or panel
step 7:
Chairing a meeting

* 1 . . . You're tapped to talk

You've been asked—or requested—to speak. Gradually the numbing fact filters through. What do you do? How do you begin?

It's exactly the same, whether you're reporting to the boss, a committee, or the board of directors . . . whether presenting a technical paper or making a speech. You put the talk together this way:

1. Decide on subject and approach.
2. Make notes of what you know.
3. Fill in with research.
4. Tie it all together with an outline.
5. Write out the talk.
6. Convert it to speaking notes.
7. Study the notes.

Some of this can be shortened if you know your subject extremely well, have considerable speaking experience, or know the listeners. But skip a step at your peril!

First, a title. Picking the exact one is *not* easy. It should distill your subject, suit the audience, intrigue them into coming. For example, my visit to Russia was reported to our readers under the headline, "How Moscow Designs." But my speech titles, all covering the same base data, included: to a heterogenous engineering group, "The Russian Engineer—How He Lives and Works"; to tool engineers, "USSR Machine Tools and Tooling"; to executives, "The Soviet Economic Threat"; to management, "Tovarishch and the Carrot"; to a general group, "The Russian Worker Today."

Language and technique vary with the subject, the group and the occasion, just as the title does, but this makes no difference in your preparation. You want to convey information. Now, communication is a two-way phenomenon; you must tell, and the audience must hear and understand. So you cannot just "be yourself" or "be natural," as some teachers advise; only an infant is entirely "natural." You must convey the information in logical order, at a rate within the ability of your audience to absorb it—they cannot look back as a reader does to refresh his memory. You must use words and phrases your audience knows. You must illustrate your points by examples, case studies, parallels, anecdotes. You must show interest and enthusiasm, or you will not be believable, and the audience will lose interest. Let's illustrate these points with an example from the turbine field:

As WRITTEN to engineers: Clearance between Vitallium buckets and vanes is 0.001 in. ±0.000,15.

As SPOKEN to an engineering audience: Rotor buckets and stator vanes are both of Vitallium, a cobalt-chrome-moly alloy with a hardness of 60 Rockwell C and thermally stable well above 1500 F. Clearance between buckets and vanes is one-thousandth inch, plus or minus a tolerance of only one and a half tenths of a thousandth.

As SPOKEN to a general audience: Blades on the turbine rotor, or rotating part, are called buckets, and those on the stator or stationary outer rings are called vanes. Both are made of Vitallium, a very hard alloy originally developed for dental bridges, but found also to be very stable and strong at the high temperatures in the turbine combustion zone. This material must be melted and cast to shape, then is so hard the casting can be smoothed only by tedious grinding. Yet the buckets and vanes must pass each other at 900 mph—missing by no more than a third of the diameter of a human hair.

So much for that; let's get on with your speech. Start by thinking what you'll want to say to fulfill your title, and enter these ideas on 3 x 5-in. cards. Carry the cards wherever you go, and as your subconscious, stimulated by your initial thinking, comes up with ideas, words, phrases, anecdotes, and the like, write them down. Don't rely on memory. This is particularly true of the anecdotes and special phrases that will give your talk color and life. The cards can be sorted and re-sorted as you change your order of ideas—that's why cards rather than a notebook. And the constant presence of the cards in your pocket will remind you regularly. As you sort them, you will see gaps where information is needed.

When your ideas begin to crystallize, transfer the card contents to a rough outline, so you can get the feel of your talk. This may be preparation enough for an informal report to the boss or for a company conference, but if you have a time limit or must show at your best, you're going to have to write out the speech. And that's next week's subject . . .

***A reprint will be available** including all seven lessons in this series. To reserve a copy circle P42 on the Readers Service Card.*

ONLY SQUARE D STARTERS WITH ONE-PIECE OVERLOAD RELAYS GIVE ABSOLUTE PROTECTION!

• Only Square D makes thermal overload relays with 1-piece construction—and only with 1-piece construction can you *know* you've installed the heater correctly. Square D 1-piece overload relays can be installed only one way. They are factory-assembled, individually tested and calibrated, completely tamper-proof. Repeated tripping will not affect accuracy.

You *pay* for overload protection—be sure you *get* it. Insist on Square D 1-piece overload relays for *absolute* protection.

Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.
Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

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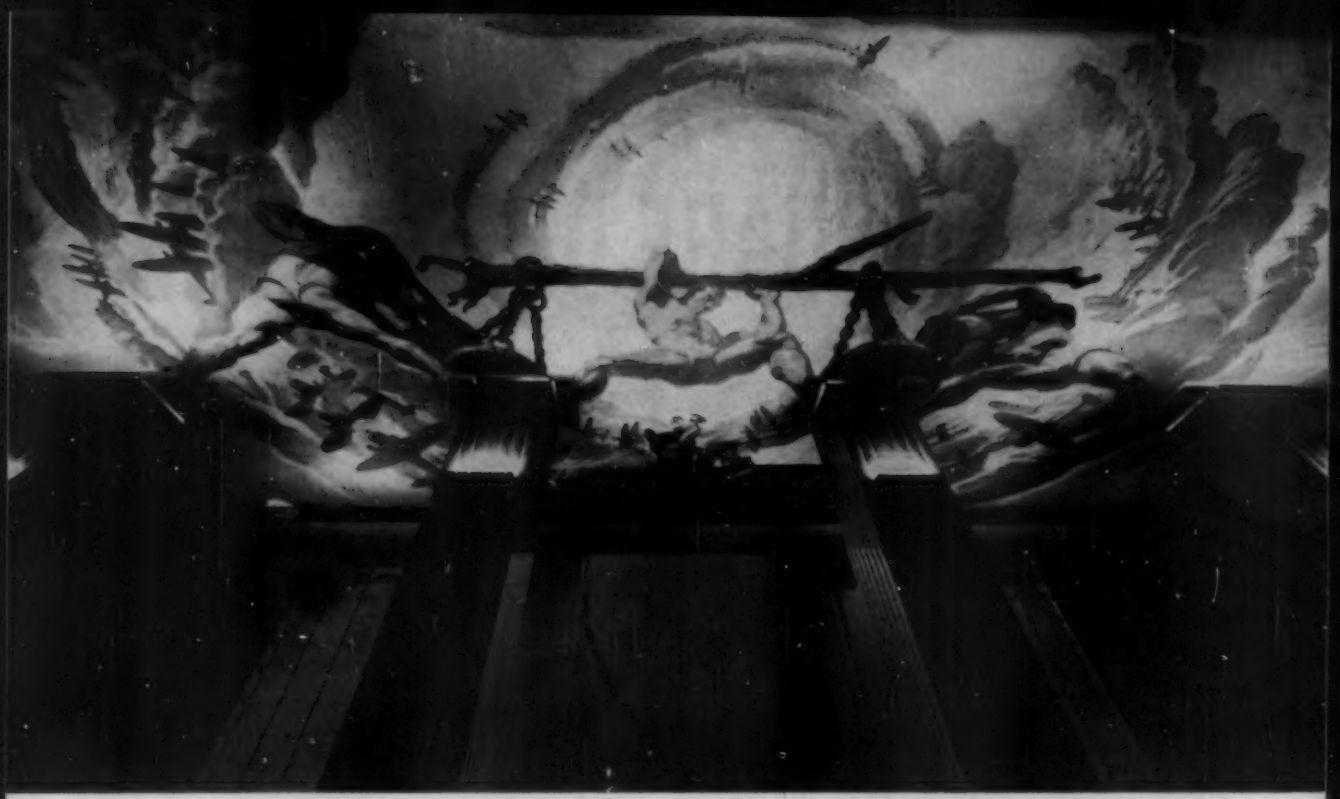


Depth on a flat surface is achieved with startling effect in this mural, by artist Jose Maria Sert, painted on the lobby ceiling of the RCA Building, Rockefeller Plaza, New York. Careful delineation of perspective and subtle shading give an impression of depth; figures poised on the columns seem to change position as the mural is observed from different angles. Stand between columns and look up and the figure directly above distributes its weight equally on the columns; look at the same figure from an angle, and the straining man has apparently redistributed more of his load to the column farthest away from the viewer.

picture it the easy way with

PERSPECTIVE GRIDS

Professional artists and illustrators draw in perspective because it shows the object with photographic accuracy. Engineers don't—because it's too difficult, takes too much time. With the gridded sheets described by the author, perspective views are a practical pictorial tool.

T O McCARTNEY, *president*
Perspective Inc, Bellevue, Wash.

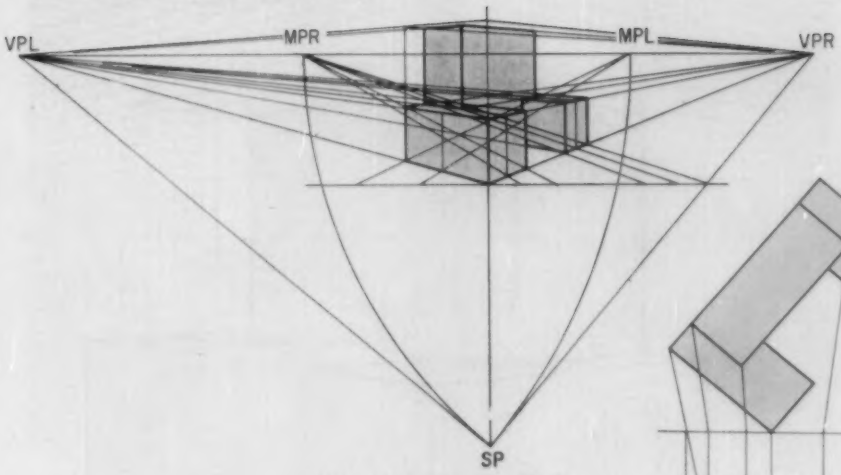
Though centuries old, the theory of perspective is a sophisticated tool for planning today's products. Delicately refined and ingeniously executed, it can help an artist create a startling illusion of depth, a feeling of reality that you can hardly duplicate except in a wax museum. To create this effect, artists rely not only on linear perspective—mechanical relationships of line and form—but also on aerial perspective, the impression of space with delicate shadings of color and distinctness. All "mechanical" pictorial methods suitable for product design have the drawback of compromising realism to gain lower cost—but this system of grid sheets minimizes the compromise.

PICTORIALS LACK PERSPECTIVE

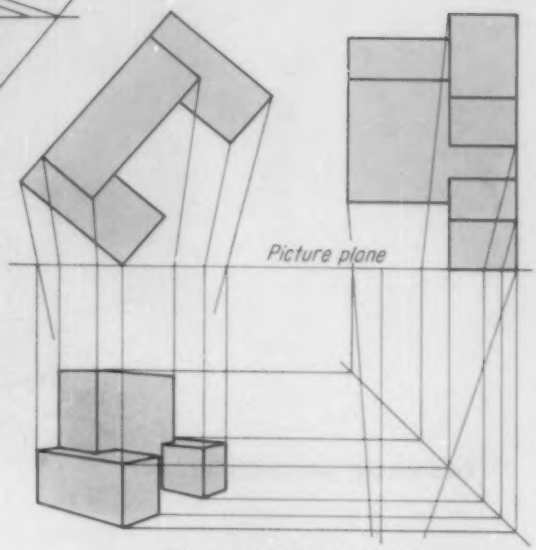
Pictorials made with common drafting room methods are always slightly distorted—some so badly that it is better to try to picture the item from the three conventional views. The two most common types of non-perspective pictorials, oblique and isometric, both have the advantage that true dimensions can be laid out on all three axes. Although the isometric gives the most accurate picture of the part, both methods cause a certain amount of distortion.

Isometric drawings give a reasonably true picture because all three major planes are tipped away from the viewer at the same angle, causing all lines to be equally foreshortened. There is some distortion because there is no allowance for perspective effects. Isometrics are drawn on reference axes spaced 120° apart. Major axis is commonly oriented vertical, but can be rotated to other angles to allow for peculiarities of a particular drawing. Biggest difficulty of isometric drawing is that circles on any plane

Two Perspective Methods



Measuring-plane method



Plan-projection method

must be drawn as ellipses. This operation can be speeded up, however, with an ellipse templet.

The oblique drawing avoids ellipses in the front face. One plane of the part is seen parallel to the viewer and circles on this plane appear as true circles. The depth axis may be at any angle to the horizontal but 45° and 30° are most common. In any event there will be distortion, causing the object to look deeper than it actually is. To avoid this, obliques are sometimes drawn with distances measured on depth axis reduced to one-half (cabinet drawing) but this usually makes the object look too thin.

PERSPECTIVES THE OLD WAY

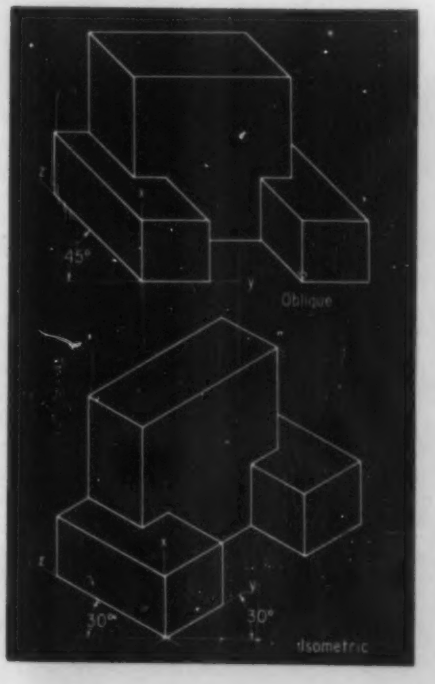
Properly executed perspective drawings do not distort but are almost unheard-of in the drafting room because they are awkward and their preparation is time consuming. In addition, most draftsmen are not sufficiently familiar with the rules of perspective to prepare a properly proportioned perspective drawing.

Perspectives require a large drawing area, many mechanical steps, a thorough knowledge of perspective theory, and so many construction lines that most of the drawing effort is discarded when the perspective view is completed. Artists and illustrators usually make perspective drawings by one of two methods. **"Plan projection" method** develops a perspective view from two orthographic views of the object. Two station points represent the eye of the observer with respect to the two views. Rays from the object to the station points pass through the picture plane where they are projected to the perspective view.

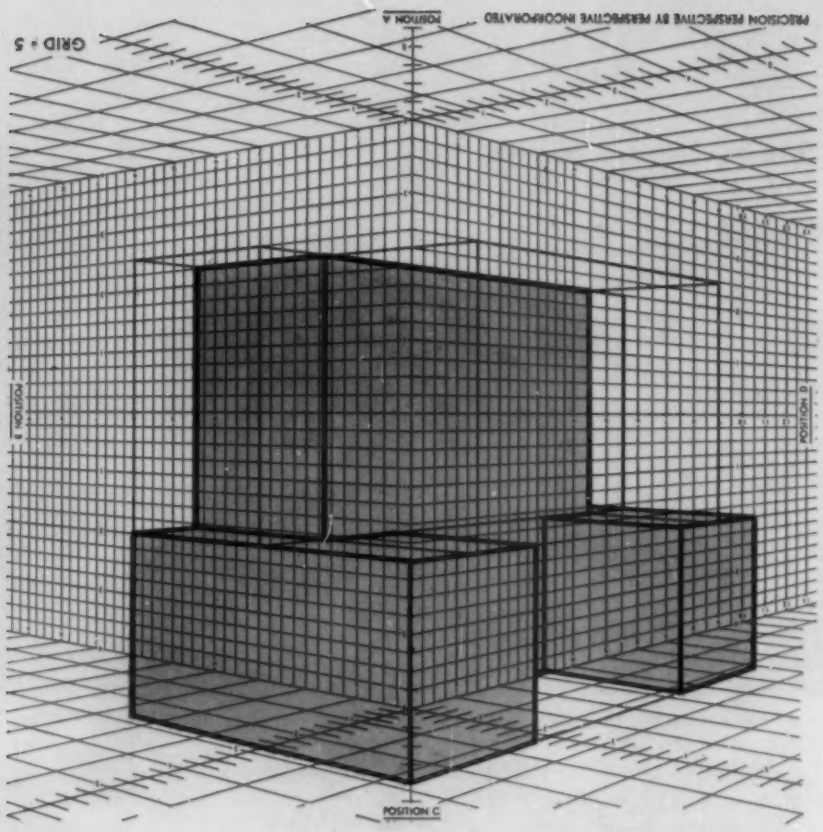
With the **"measuring plane" method,** constant-dimension planes are drawn in perspective. These carry dimensional information from the picture plane to vanishing and measuring points in the perspective view. Either way,

(Text continued next page)

Mechanical Pictorials



GRIDS GIVE PERSPECTIVES THE EASY WAY



two-point perspective

the three-dimensional picture is usually more trouble than it's worth for engineering purposes—particularly when, with isometric or oblique drawings, the pictorial view can be made quickly and easily without too much annoying distortion and a minimum number of construction lines.

PERSPECTIVE GRIDS—FASTER

But any draftsman can follow guidelines. That's the premise on which the perspective grids shown here are based. First step is to lay out each of the orthogonal views on the grid by following lines on the three mutually perpendicular perspective planes. When these views are projected toward each other, the intersecting lines form the outline of the perspective drawing. Details are added later. Arcs and curves can be drawn by plotting them on the gridwork and projecting them in the same way.

Grids can be constructed by drawing a perspective view of three mutually perpendicular planes rotated or tilted to the desired angle with respect to the observer. Planes are ruled with squares of a convenient size and can be drawn with either one of the basic construction methods.

In practice, the grid is placed under the drawing vellum and the draftsman lays out side- and end-views of the object, tracing the outline from the lines on the perspective planes. These views are then projected across to develop the object in three dimensions. Expansion of this simple technique permits construction of very complex subjects.

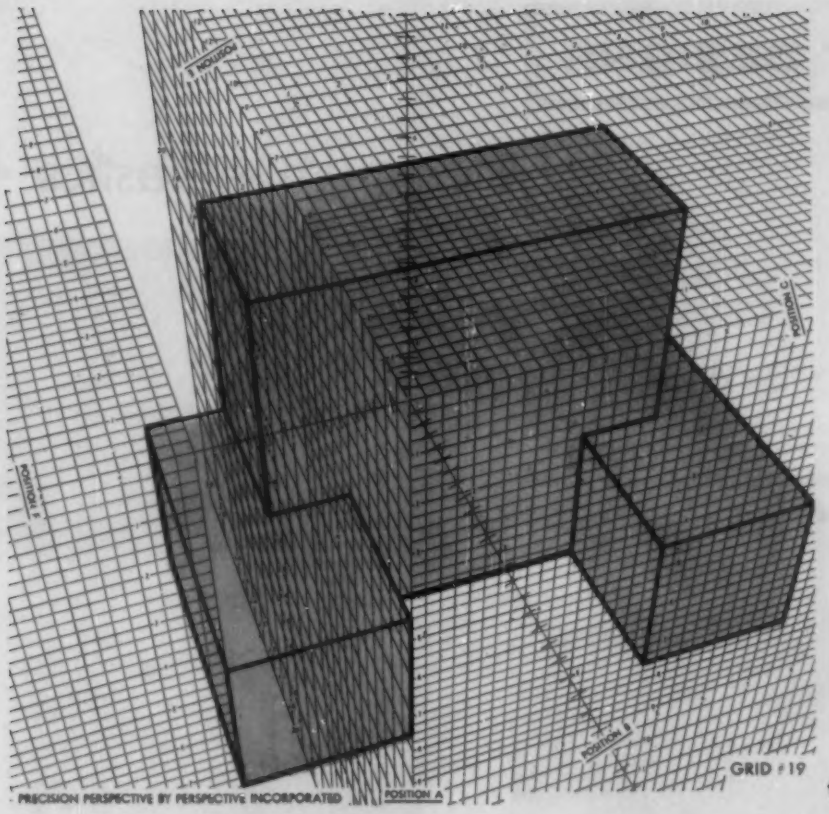
Three-point perspectives have all three planes tilted with respect to the observer, allow an infinite variety of subject position. They are very difficult to draw with conventional methods, but when construction lines are traced from a grid, they are actually easier to lay out than two-point perspectives.

Choice of angle depends on shape of object and the surfaces that need to be seen. As shown in the accompanying chart, a wide variety of views is available; each cube represents the angle available with one particular grid. Each grid, then, is actually a multiple grid; the same three-point perspective grid can be rotated through 6 positions to give 16 different views.

PERSPECTIVE PLANNING

Perspective drawings are commonly made by imagining that rays from each corner of the object converge at a point called the station point. Between the object and the station point is an imaginary plane where the image is formed; rays cutting this picture plane establish a reduced-scale outline of the object. If a perspective drawing is to appear as a true image, it must be located so that the eye of the observer is at the same position in space as the station point was when the picture was drawn. A drawing made with station point and picture plane 9 in. apart, for example, will appear distorted when viewed from any other point in space.

This distortion is not evident to the untrained eye because we have learned to make mental corrections for distortion caused by off-axis viewing. Photographs, for example, should be viewed with the same relative eye position as focal point of the camera was to the film when

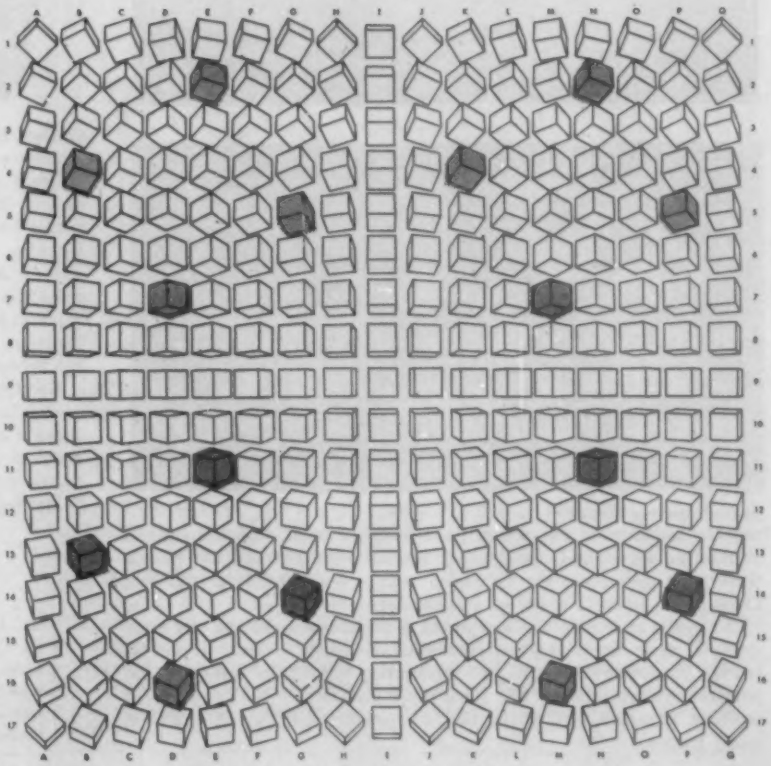


three-point perspective

the picture was taken. But even when viewed at sharp angles, photographs look natural to most people. The effect of this distortion becomes most pronounced in telephoto photographs where background and foreground seem to merge; objects that are actually many yards behind the object in the foreground seem only a few inches behind. Telephoto photographs give a true image only if placed at a great distance from the observer.

Minimum viewing distance for most people is 18 in. when max dimension of the drawing is 9 in. or less. For larger drawings, comfortable viewing distance is usually twice the max dimension of the drawing.

PRECISION PERSPECTIVE GRID SELECTOR CHART



EDITOR'S NOTE: For more information about pictorial drawings and drawing shortcuts see:

Design It in 3-D, Aug 25 '58, p22. Why pictorial drawings simplify communication for the benefit of management, salesmen, other engineers.

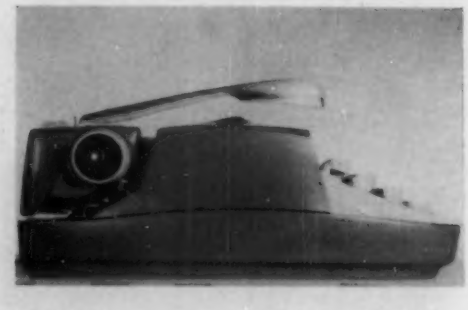
13 Ways to Cut Drafting Costs, Sep 28 '59, p 54. Latest tips, tools, techniques that reduce time and expense in the drafting room.

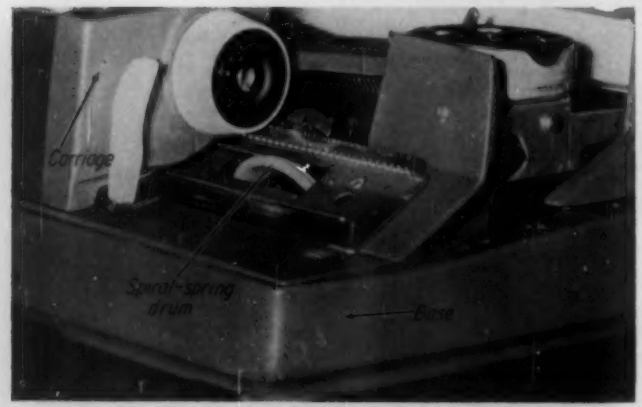
PRODUCT DESIGNS

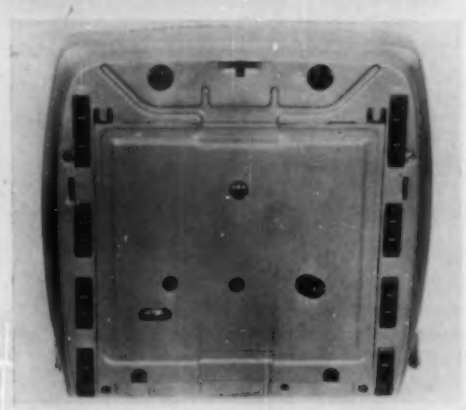
Aluminum + Plastics =

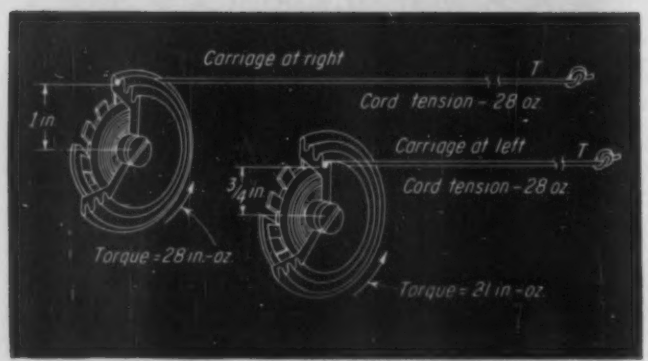
EXAMPLE— WEAR-RESISTING TYPEWRITER

The 85 plastic and 16 aluminum parts of the portable machine reduce weight and ease operation. Resonance is also reduced, permitting practically noiseless typing.









Spiral-spring drum . . .
provides uniform carriage action throughout its travel. In conventional mechanism, by contrast, carriage-cord tension is reduced and the carriage slows as it approaches the right-hand margin position. It is this that causes a fast typist to crowd or jam the keys.

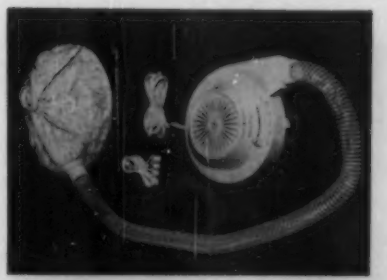
When the carriage in this new model is at extreme right (A), the mainspring is fully wound up and produces maximum torque. With the carriage at extreme left, (B), the mainspring is partially unwound and produces reduced torque. The spiral drum that reels in the carriage cord produces a variable lever arm that compensates for the reduction in spring tension.

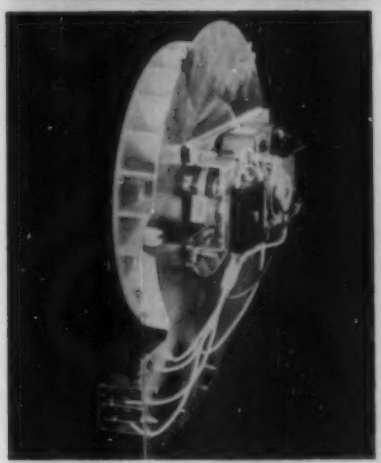
Sealed base . . .
is aluminum sheet interlaced with rubber strips stapled in place. They replace conventional rubber knobs, to cut down vibration and decrease height. Wire staples hold the strips to base, providing inexpensive fastening and speed assembly. Die-cast aluminum segment in which the typebars are mounted replaces conventional cast iron segment. Shifting, which requires pressing down the shift key with the little finger to raise the segment, requires less effort with the lighter casting.

Key tops, roller knobs, keyboard backing and other control handles are made of matching plastic to provide abrasion resistance and attractive appearance. Plastic guard around the keyboard replaces painted metal guards previously used and gives superior resistance to staining and scratching.

PS . . . The new "Galaxie" is 1 in. wider, ½ in. lower, and its 12-lb weight makes it a pound lighter than the lightweight portable it replaces. The carrying case of vinyl-covered aluminum helps keep weight low. Produced by Smith-Corona Marchant Inc, Syracuse, NY.

Lightweight Efficiency

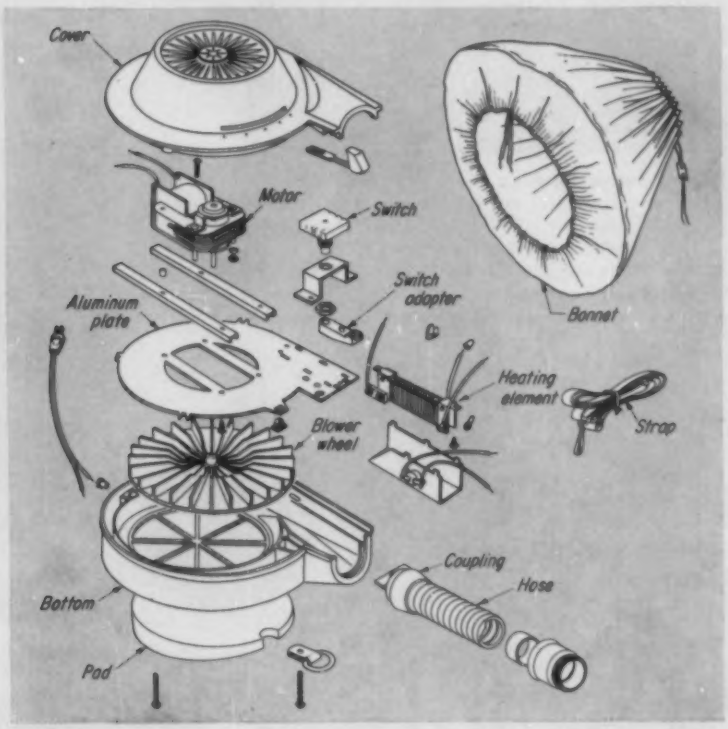




Backbone of the dryer . . .
is a punched aluminum motor-plate around which the entire power unit—blower, heating coils, and switch—is assembled. In addition, the plate acts as one side of the blower shroud formed by base of the unit. The heater-cover is sheet aluminum. It has tabs that pass through slots in the motor plate, then are twisted to hold the cover. The power unit is assembled by dropping the motor-plate assembly into the base, placing the cover on top, and installing five screws.

EXAMPLE—
EASILY ASSEMBLED DRYER

Plastic parts are fitted to an aluminum backbone in this walk-around hair dryer. Dual-wall construction of bonnet provides even air distribution.



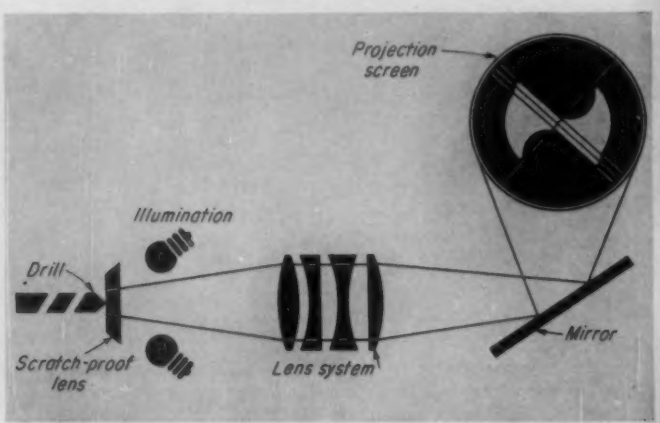
Volume production . . .
of this common household appliance permits using complex plastic-injection moldings even though they require expensive dies. For strength and appearance, cover, base, and blower wheel are high-impact resin-rubber compound. Hose couplings, switch adapter and grommets are nylon and linear polyethylene for strength and abrasion resistance. Wire-reinforced hose is transparent vinyl for flexibility and heat resistance, plus an attractive appearance. Foam vinyl is used for the pad comented to the base of power unit. The bonnet is formed of a clear vinyl liner and an outer translucent cover printed to resemble fabric. Air passages are formed between the liner and cover of the bonnet by fusing the two together. The liner is perforated to provide even air distribution.

PS . . . The portable hair dryer rests on table or can be suspended from waist or shoulder by carrying-strap. Power unit weighs 3½ lb, measures 3⅜ x 8¼ in. Bigger blower moves a larger volume of air at lower speeds to reduce noise usually associated with hair dryers. Home Hair Dryer, Model HD-1, is produced by General Electric Co, Automatic Blanket and Fan Dept, Bridgeport, Conn. (For first data on high-impact rubber-resin compound, see PE—June 8 '59, p 76.)

Built-in Checker for Dull Drills

Its optical system shows operator exact condition of drill point. Concentric sharpening is accomplished in 10 seconds; inspection takes 2 to 3 seconds more.

Jointed swivel arm . . .
swings drill between grinding and inspection positions. Dull drill is inserted in collet at the end of the swivel and is checked on the viewing screen for concentricity. Then, if the cutting edges are in line with the cross-hairs, the swivel may be flipped over to grinding position. A feed adjustment on the swivel holds drill at desired angle during grinding. Mounted on the wheel guard is a diamond-point wheel dresser operated by a hand lever.

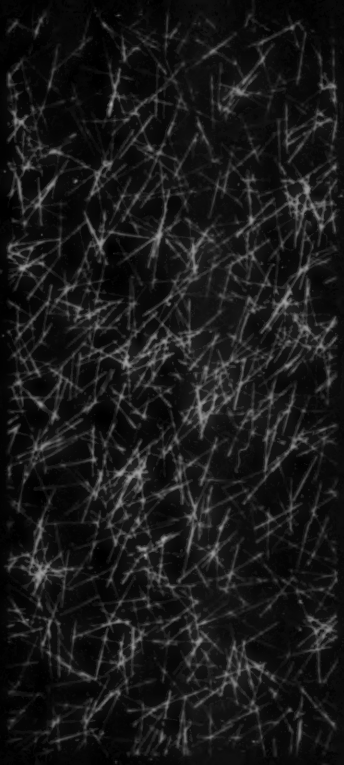


Amplified image . . .
of drill being sharpened is projected on the screen in front of the operator. After a pass across the grinding wheel the drill is in position (A), in front of the viewing lens, for a quick visual check on the condition of its edge. Concentricity can be checked (B) by rotating the drill in its holder. Cross-hairs on screen provide operator with necessary reference points.

A

B

PS . . . The Tartar drill sharpener is available for either right-hand or left-hand twist drills. Two collets handle all sizes from 1/64 to 25/64 in. Developed by Alexander Tatar, Stuttgart, W Germ.



A PRODUCT ENGINEERING SPECIAL REPORT

which process for...

fiberglass-reinforced plastic molded parts

Have you side-stepped glass-reinforced plastics because of uncertainty about which process is which? If so, here's up-to-date guidance. The author selects 7 key processes out of the 15 now available, explains their strong and weak points—and shows how one or the other becomes the logical choice in most commercial-volume applications.

G S McELROY, *manager Reinforced Plastic Process Engineering, Owens-Corning Fiberglas Corp*

With all their advantages, fiberglass-reinforced plastics (FRP) have an unusual drawback. The 15 competing ways to fabricate with these glass-resin mixtures add up to too much of a good thing—a complexity that often sidetracks the designer to some other material. But once you recognize that the basic methods belong to a unified family, the choice is easier. You can then give the FRP's the evaluation they deserve as engineering materials that simplify product design. This article identifies present fabrication processes, relates them to each other, and shows how most commercial applications usually boil down to selecting one of the seven basic techniques.

Like other processes where a material is shaped while it's being manufactured, FRP fabrication is not yet an exact engineering technique. Here, the problem is further complicated by the need to dis-

tribute a glass matrix uniformly within the plastic so as to create an essentially isotropic material with a strength nearly comparable to that of the low-cost metals.

Experience over a decade in meeting this problem has demonstrated FRP's basic advantages for industrial components: a favorable strength-weight ratio, good dielectric properties, good corrosion resistance, high impact resistance, translucency, a favorable cost/performance combination, and ease of combining parts to eliminate assembly costs and simplify design.

The same experience, however, reveals five basic problems that, to greater or lesser degree, must be recognized by the product designer when specifying FRP.

• **High raw-material cost.** Glass and polyester resin mixed ready for molding costs about 35 cents/lb, compared to about 6 cents for carbon-steel sheet and 50 cents for aluminum sheet. FRP does more jobs per pound, but its present cost still blocks it from many applications where the cheaper competitive materials give "good enough" performance. FRP cost promises to drop as new raw-material manufacturing processes develop and as volume usage rises, but will probably always remain above the base price of the common metals. Use of lower cost spun roving is increasing.

• **Variations in raw materials.** Resin chemical reactions are hard to control both in manufacture and in molding—rapid and uniform reaction to catalysis, and good fluidity in the mold are needs essentially in opposition to each other. With present processing, glass roving and mat vary too much in unit weight, ease of handling, and amount of resin binder. To narrow these variations, new resins are being developed that are faster curing and less critical, and new controls on the glassmaking processes look promising.

• **Long molding cycle.** Chemical crosslinking makes FRP's stronger than thermoplastics but requires a cure time that slows production. Until faster curing resins are developed, faster production needs must be met by picking the fastest process or by multiplying presses or molds—thus upping investment costs.

• **Property limitations.** Inherently, by nature, the polyester-glass materials tend to have low wet strength, limited resistance to heat and fire, a fibrous appearance, and a low elastic modulus. The first two limitations have been pretty much licked. Silane and organic chromium coatings for the glass have markedly improved wet strength. Fire resistance is possible through additives or specially manufactured resins themselves. The last two limitations depend upon how the glass is positioned in the part. Special surface layer techniques are used to control appearance.

• **Positioning.** Key problem of most FRP processes is how the glass is placed in the mold and held there while the resin flows into place and gels. High glass content and favorable distribution of the fibers give maximum strength. In any of the processes, getting the glass into the part accounts for most of the direct labor.

UNITY IN COMPROMISE

The five problems are common to all of the 15 processes that you can use today. Each process in use today is a compromise to gain a large or small improvement in one or more of the limiting factors on this list. The compromises are invariably made at the expense of higher costs to gain performance, or the reverse (Table I).

Hand Lay-up, for example, was the earliest process in the family and still gives high-performance laminates because of the high glass content achieved when using cloth. However, much labor is expended, positioning the glass precisely. To cut cost of this labor, a new process was designed. Called Air Preform, it blows chopped glass at a screen shaped like the part to be made. This cuts costs but lowers performance, too, because the glass/resin ratio is reduced. Uniform distribution of glass is also a problem. So Air Preform, in turn, led to the recently developed Wet Slurry process for making preforms, which gives closer control over fiber distribution at some compromise in cost.

The cost/performance spectrum covered by these 15 processes is seen quickly in the five-class breakdown of Table I:

• Low-cost processes held back by modest performance, where competitive materials offer "good enough" performance at a lower price.

• Medium-cost processes where performance problems have been partially overcome.

More Design Data on the Way

"Fiberglass-reinforced plastics fabrication is still too much cut-and-try," says author McElroy, "and not the engineered technique, which it must become." To speed the day when FRP fabrication is mature, Owen-Corning Fiberglas in 1956 inaugurated a broad engineering development program. A comprehensive evaluation of FRP processes, the basis for this article, was made by McElroy as a logical step in this program.

Setting reliability standards is a second important part of the effort to put FRP on a sounder engineering basis. Here OCF has organized a team of 14 organizations in a long-term program (See *PE—Feb 3 '58, p 69*) of a data-gathering and statistical analysis to establish properties based on sound confidence limits.

A third phase of the program is the OCF reinforced-plastics Design Data Series—manuals for designers published in cooperation with McGraw-Hill Publishing Co. Two of these are already available: "Adhesive Bonding of Reinforced Plastics," by H. A. Perry (See *PE—July 7 '58, p 64*) published in 1959; and "Marine Design Manual for Fiberglass-Reinforced Plastics," by Gibbs & Cox Inc. Just published, this second volume contains the first design data collated from the OCF reliability standards program. A third manual, "Mechanical Fastening and Machining of Reinforced Plastics," is being prepared.

The fourth major phase is a cooperative technical assistance program in which OCF and various molders, resin manufacturers, and users of FRP seek ways to eliminate material and process variations. This includes continuing OCF development of the fiberglass-making process to get lower cost and more consistent products.

• Newly developed, medium-cost processes that have not yet found their ultimate place in the spectrum.

• High-cost processes employed most widely in military applications to gain high performance.

• Limited-application processes.

So far, the four new processes listed have developed rapidly and may move soon into other categories. Both Spray-up and Wet Slurry will probably become medium cost–medium performance techniques, while Filament Winding will apparently remain a high cost–high performance method. Automatic equipment can lower cost here, however.

All the processes, particularly the seven basic ones, are complementary; each occupies a place in the spectrum and overlaps another to some degree. Newer processes are not necessarily better than the older ones; each category supplies something the other lacks. Some processes, of course, turn out to have limited application, or are too costly for commercial-volume production, and are reserved for the special jobs no other technique is able to handle efficiently (Table II).

Whether they overlap or not, the processes often compete for the same applications. Proponents of each process work hard to convince the designer that the compromise represented by their process has the best chance of meeting his needs. This means the designer must: know each process and how it works; understand the compromise that brought it into being; and know its main advantages and limitations.

The accompanying ready-reference chart (Table III) identifies the seven basic processes for fabricating FRP and allows a comparison of their strong and weak points at a glance. The advantages and limitations are a detailed expression of the compromise each process makes in order to score a gain on one of the five basic limiting factors. No attempt has been made to list these points in their order of importance–a subject of wide debate, even among experts.

COSTS–A ROUGH COMPARISON

The curves on page 55 show the results of a simplified cost comparison of four FRP processes applied to three typical parts–small, medium, and large–over a wide volume-production range. The ordinate gives cost ratio, because the actual dollar-per-piece figures depend upon actual overhead rates and know-how for individual plants. However, for comparison purposes, the study is useful on two counts: A single estimating system was used; and uniform

(Text continued on page 55)

Table I–The Fifteen FRP Processes

- **Low cost–modest performance**
  1. Premix
  2. Injection Molding
- **Medium cost–good performance**
  3. Air Preform
  4. Hand Lay-up
- **New Processes–recently developed**
  5. Wet Slurry
  6. Spray-up
  7. Filament Winding
  8. Contour Weaving
- **High cost–high performance (with cloth)**
  9. Vacuum Bag
  10. Pressure Bag
  11. High-pressure Laminating
- **Limited-application processes**
  12. Autoclave
  13. Rubber Plunger
  14. Potting and Casting
  15. Centrifugal Casting

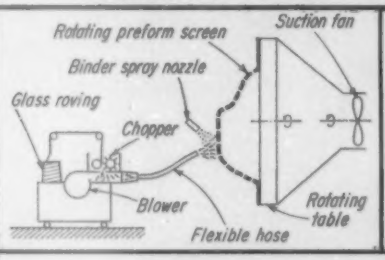
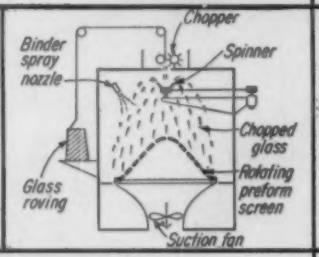
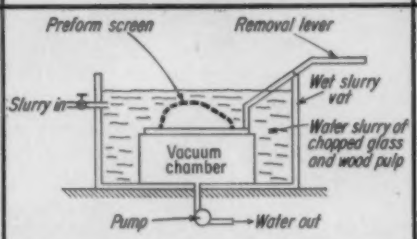
Table II–Specialty FRP Processes

(Molding techniques that have restrictions, thus far, in high-volume production for the reason given)

Rubber Plunger	Configuration limitations restrict application.
Vacuum Bag	Costs too high, except for military high-strength applications. Good for large parts and prototyping.
Pressure Bag	Limited application, for large parts. Good for hollow shapes.
Autoclave	Investment costs too high, despite higher glass loadings achieved and labor cost reductions.
Potting and Casting	Limited application for molds, tools and fixtures.
High-pressure Laminating	Limited application; primarily in flat sheets for the electrical field so far.
Centrifugal Casting	Limited application, primarily in specialty-pipe field so far. Excellent control of glass/resin ratio achieved.
Injection Molding	Major technical problems: surface finish, uneven glass distribution, and low level of reinforcement. Excellent progress now being made in compounding and strand integrity.

Table III

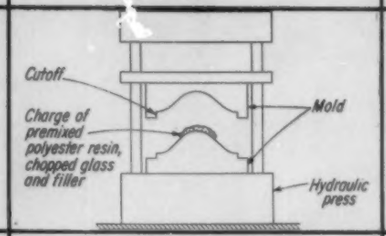
CLOSED-MOLD PROCESSES

	Air Preform		Wet Slurry
	Directed Fiber	Plenum Chamber	
			
PROCESS DESCRIPTION	Air Preform process forms chopped strands into a blanket that is shaped like the part to be molded. Either the plenum-chamber or directed-fiber system is used. Both systems create a vacuum behind a rotating screen that conforms to the part shape. Plenum-chamber system floats glass strands on screen; directed-fiber system blows them on with a hand-held nozzle. Directed-fiber system gives best fiber distribution when part is large and highly assymetrical or complex. With both techniques, suitable binders are applied during and after the cycle to make preform easy to handle. Preform is then oven-baked to strengthen it for further handling and prevent wash-out of fibers during molding cycle. Part is made by fitting the cured preform into matched metal dies, adding catalyzed resin, and press-curing.		Wet Slurry process mixes chopped glass strands and wood pulp in a diluted resin or water carrier. Wood-pulp additive is a filler and binder; gives strength for handling, along with higher impact resistance. Metered amounts of strand and pulp (in predetermined ratio) and water are collected on a screen form by pressure or vacuum. Resulting felted blanket is then dried prior to molding. In vacuum system, further strength (and sometimes a decorative effect from colored strands) is achieved by precoating glass strands with a suitable resin. Final part is formed in matched metal dies, as with air preforms.
ADVANTAGES	1. Most efficient method for placing glass in mold 2. Screens are fairly easy to design; abrupt shape changes can be handled 3. Cheaper than mat preforms, except on flat parts 4. Low investment cost		1. Uniform density of glass-pulp mixture possible, regardless of varying section thickness; thus glass/resin ratio is constant 2. Glass-pulp ratio can be varied 0-90%, permitting lowest possible glass content and low material cost 3. Cellulose fiber (pulp) additions give improved impact strength 4. Cross-section of preform can be varied (corners, ribs, bosses, etc.) to suit performance requirements 5. Low waste; edges are preformed, so "pinch-off" at die closure is eliminated and die edges need not be hardened 6. Process can be automated, reducing direct labor cost
LIMITATIONS	1. Uniform glass thickness hard to maintain (because of limitations in process); this upsets glass/resin ratio in spots 2. Fibers close to surface sometimes esthetically objectionable, and sometimes "bloom" as resin weathers away 3. Glass waste is high (5-8%); screens require cleaning 4. Restrictions on size and shape for air-plenum preforming 5. Raw-materials cost a high proportion of total cost		1. Short runs less economical, owing to additional cost of equipment for shaping preform and for water removal 2. Possibility of wavy surface finish, with fibers prominent 3. High cellulose-fiber content lowers tensile strength 4. Vertical walls hard to form and tend to sag unless most water is removed and preform is baked quickly

Seven Basic Processes for Fabricating Fiberglass-reinforced Plastic Parts

OPEN-MOLD PROCESSES

Premix

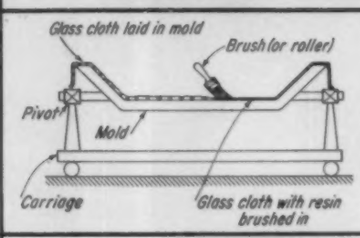


Premix process combines the intricacy of part design found in thermoplastic molding with the strength of reinforced thermosets. Resin, reinforcement, filler and pigment are blended into a putty-like mix (or a dry granule mix in the case of most common commercial molding compounds). Premixing molders feed the compound in the form of pre-weighed globs or ropes for each cavity, from their own mixing rooms directly to the molding room. Premix compounders, in contrast, sell high-performance standard mixes—inhibited to provide greater shelf life — to the non-compounding molder. When glass is the reinforcement, fibers ¼ to ½ in. long are used; sisal and asbestos, as well as glass-sisal-asbestos combinations, are popular. Fillers ease flow, lower cost.

1. Highly complex parts are possible, with varying wall sections, inserts, ribs, bosses, threads, etc.
2. Raw-material cost fairly low
3. Direct labor cost is low since preform step is eliminated; however, mixing step (small cost) is added and presses should deliver 300-500 psi
4. Proportion and type of reinforcement can be easily varied, depending on performance needed
5. Post-molding shrinkage is very low

1. Strength is low compared to air preform-match die molding, and only slightly higher than glass-filled phenolics
2. Nonuniform dispersion of reinforcement can be a problem
3. Tendency for as-molded surface to be rippled, mainly in higher-impact premix compounds (improvements here due soon)
4. Thin sections are a problem

Hand Lay-up

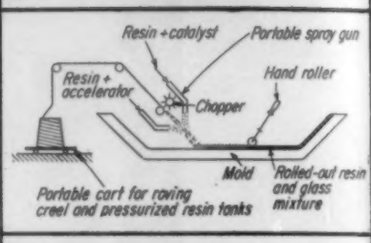


Hand Lay-up is the oldest and simplest technique for fabricating FRP parts. A mold is constructed of wood, epoxy resin, plaster or other easily worked materials. Mold can be either a cavity or a positive shape. If a cavity is employed, and a smooth finish on the part is required, a thin coat of resin is sprayed into the mold to form a gel-coat. Chopped-strand mat or woven cloth is then laid into the mold by hand—carefully tailored if necessary — and catalyzed resin applied by brush or spray gun. Curing takes place in air, in a vacuum bag, or in an oven. Autoclave curing permits higher glass concentrations. Hand Lay-up finds use in large structure like boat hulls, radomes, machine housings—as well as in prototyping, and for low-volume production.

1. Ideal for parts too large and complex for press molding
2. Well suited for low-production runs
3. Style or design changes easily made
4. Low investment required

1. Expensive because labor is high and costlier glass forms are used
2. Skill required to avoid wrinkles and overlap, and get uniform glass/resin ratio
3. Lay-up and curing necessarily slow

Spray-up

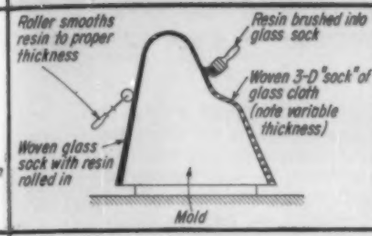


Spray-up was developed to replace Hand Lay-up by overcoming its major limitations. Instead of glass mat or cloth — roving is drawn from a creel, fed through a chopper and blown at the mold. Resin-system ingredients are injected into the glass stream by either of two basic spray guns: first employs two metering nozzles — one carrying resin premixed with catalyst, the other carrying resin premixed with accelerator; in the second gun, ingredients are fed separately into a mixing chamber just ahead of a single spray nozzle. By either method, resin mix coats the glass strands and the merged spray is directed evenly into the mold by the operator. Glass-resin mass thus applied is then rolled out by hand to remove air and pack mix to uniform thickness. Cure follows.

1. Strength about equal to that obtained with mat Hand Lay-up
2. Often cheaper than Hand Lay-up vacuum-bag process
3. Good for large complex shapes with negative draft
4. Cheaper than matched metal-die molding in low quantities
5. Not dependent on metal dies, thus offering quicker delivery potential and freedom for design changes
6. Well suited to prototypes, small volume production, and protective coatings
7. Equipment portable, and total investment low

1. Surface away from mold is rough
2. Glass content limited to 50% max so far (30-40% normal)
3. Strength about 10% below that for matched-die molding
4. Confined areas hard to reach
5. Process cannot be applied to matched metal-die process because mix is too weak to resist tearing
6. Relatively high labor cost since all areas must be rolled out in separate operation

Contour Weaving

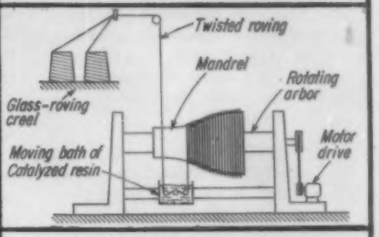

Roller smooths resin to proper thickness
Resin brushed into glass sock
Woven 3-D "sock" of glass cloth (note variable thickness)
Woven glass sock with resin rolled in
Mold

Contour Weaving, a variation of Hand Lay-up was developed for parts of broad, irregular, three-dimensional contour. In these cases, conventional glass cloth or mat do not drape well, must be specially tailored, and are hard to hold in place. In contour weaving, carpet looms have been ingeniously adapted and programmed to weave a complete circumference of glass cloth to the shape of the final object. This cloth shape is pulled over the mold like a sock (but woven, not knitted), and catalyzed resin is sprayed or brushed on as in conventional Hand Lay-up practice. Curing completes the part.

1. Strength is high because glass yarn is continuous, precisely oriented
2. Gives uniform density because contoured fabric has uniform thickness, and fits mold closely without wrinkles or seams
3. Parts can have variable wall thickness while retaining constant glass/resin ratio, since contoured fabric can be woven with variable thickness
4. Parts are not limited to surface of revolution, as in most applications of Filament Winding
5. Scrap losses and lay-up time are reduced; output per mold is increased
6. Woven preforms are cheaper than those cut and sewn

1. Hand Lay-up resin-spreading costs still apply
2. Shapes must have zero or positive draft to fit over mold

Filament Winding



Filament Winding uses continuous reinforcement to get the most efficient utilization of glass-fiber strength, compared to other processes. Glass filaments in the form of roving or single strands are fed from a creel, into a bath of catalyzed resin, and around a mandrel. Special lathes have been made that lay down glass in a predetermined pattern to give maximum strength. When the right number of layers of glass and resin have been applied by repetition of the winding cycle, the loaded mandrel is removed from the lathe and cured at room temperature or in an oven. Resulting parts are often machined to close tolerances. Preimpregnated roving is gaining acceptance.

1. Glass can be oriented in best direction for max strength
2. High glass/resin ratio possible gives high strength/weight ratio
3. Close tolerances possible because shapes are simple and can be machined
4. Can be automated, but high volume is needed to keep costs in line
5. Fusible and collapsible mandrels can give re-entrant shapes

1. Shape of parts is restricted to rounds, ovals and tapers—though limited reversed curvatures are possible
2. Joining filament-wound parts to adjacent structures is a problem
3. Process costs not yet firmly established
4. Liner usually necessary to prevent leaks in pressurized applications
5. Only specialized shapes (radomes, pipe, missile nosecones, etc.) available so far

SOME TERMS YOU SHOULD KNOW

FRP: This is an abbreviation for fiber-glass-reinforced plastic — glass-fiber strands, packed closely together, surrounded with cured thermosetting or thermoplastic resin. Glass content can run as high as 90%.

GLASS FIBERS: Borosilicate glass drawn into extremely fine (0.000,35 to .000,40 in. dia) fibers. Forming process increases tensile strength from a nominal 20,000 psi to nearly 400,000 psi, and makes fibers an ideal reinforcing medium.

GLASS ROVING: A bundle of a discrete number of strands (for example, "60-end roving," each "end" containing about 200 fibers) wound onto a spool without twist. Glass yarn is formed when strands are twisted and plied together in various combinations.

GLASS CLOTH: Glass reinforcement made of cloth woven from glass yarn. While there are over 20 standard styles, 3 weaves are most common: plain, unidirectional, and harness. Harness weave provides good biaxial strength, and drapability for double-contoured parts.

GLASS MAT: A blanket of randomly oriented lengths of chopped strands or swirled strands. Chopped strands may be ½ to 2 in. long, are "bonded" together by binders and a felting process. Mat is inexpensive and a fairly easy reinforcement to apply, especially for double-contoured surfaces. It gives an isotropic FRP, but lower strength than glass cloth because glass content is lower. Very thin mat of monofilaments is called "surfacing mat," and is used to hide the fiber pattern on some molded parts.

CHOPPED STRAND: 200 glass filaments, first bonded together as a strand in the fiber-forming operation, then chopped into desired lengths from ¼ in. to 2 in., or formed into roving for chopping, etc. Chopped strand is mixed with catalyzed resin in Premix molding.

THERMOSETTING RESIN: Usually a liquid plastic in uncured (monomer) form which chemically cures (polymerizes), into a nonfusible solid, by catalysis and/or exposure to external heat. Polyesters and epoxies, which cure at atmospheric pressure with or without application of heat, suffice for most FRP parts. Phenolics, epoxy-phenolics, special polyesters, and silicones are examples of more sophisticated resins for high-temperature or special service. These resins generally require more complex molding cycles.

CATALYST OR HARDENER: A chemical curing agent added to the resin in appropriate quantities to start the cross-linking process. The term "hardener" is generally used with epoxies; "catalyst" with polyesters, phenolics, acrylics and others. The many curing agents available can be combined with accelerators or inhibitors to speed or slow the cure.

MAT OR PREFORM RESIN-SOLUBLE BINDER: A resin coating sprayed on the chopped strand to hold it in position, oven curing follows. Other binders containing silanes are commonly applied to the strand during manufacture to bind filaments together. These silanes promote wet strength by keeping the bond dry.

LAMINATE: A multiple layer of reinforcements, either alike or dissimilar, impregnated with resin and cured. Mat is often used for the core, with cloth reinforcement as the skin for maximum strength. Several cloth layers may be crossed at 0°, 30°, 60° and 90° to give nearly isotropic, high-strength FRP. Surfacing mat is sometimes used as outermost layer to improve appearance.

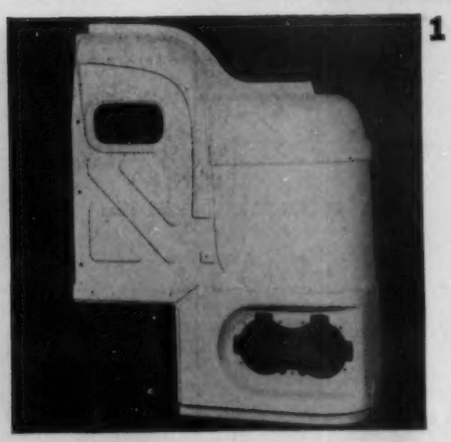
GEL-COAT: A thin layer of catalyzed resin applied to the mold and allowed to set before the glass-resin mixture is added. When properly pigmented, it gives a smooth opaque outer surface which hides the natural fiber texture of the laminate.

FILLER: Powder mineral compounds such as hydrated aluminum silicate, added to the glass-resin mix to reduce shrinkage, cut cost of material (by reducing glass content), or impart special properties to the laminate.

PREMIX: Chopped glass strand premixed with thermosetting resin, catalyst, filler, and pigment—ready for insertion into the mold. Adding inhibitors allows the premix to be stored for long periods. Sisal and asbestos fibers are also employed.

PREPREG: Glass, as roving or cloth, preloaded with B-staged resin, catalyst and pigment—and inhibited for storage. Ready for placement in the mold.

EACH FRP PROCESS A COMPROMISE—THESE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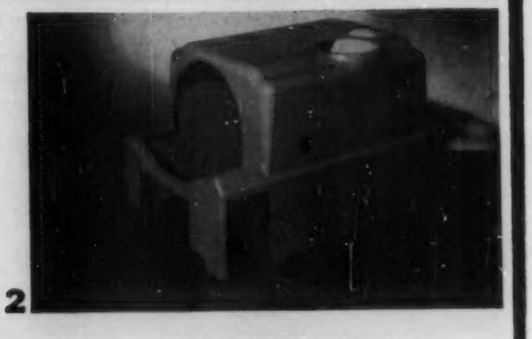
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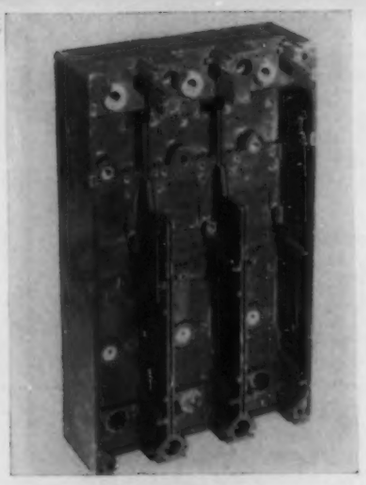
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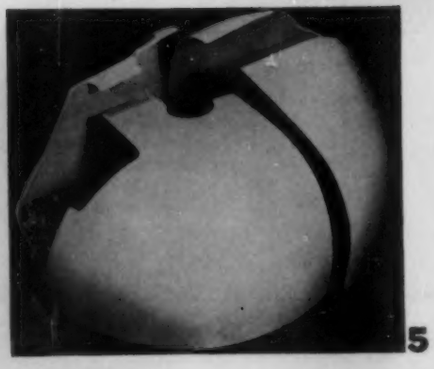
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7

TYPICAL PARTS SHOW WHY

1 Air Preform

TRUCK FENDER PANEL *is mass produced, requires an efficient, low-cost process. Slight variations in glass/resin ratio, a problem with Air Preform, do not affect performance here.* (Molded Fiber Glass Body Co)

2 Wet Slurry

DRILL GRINDER HOUSING *has intricate contour—needs close control over glass-fiber distribution for uniform strength. Wet Slurry gives it, but additional process costs discourage short runs.* (Cimastra Div, Cincinnati Milling Machine Co)

3 Premix

HEAVY-DUTY SWITCH CHASSIS *needs high impact strength, intricate detail, abrupt section changes, and inserts made possible by Premix molding. Main difficulty: nonuniform fiber distribution tends to lower strength and cause ripple surface on large, flat surfaces.* (Tech-Art Plastics)

4 Hand Lay-up

CORROSION-RESISTANT BLOWER *is a large, specialty part ideally suited to economics of Hand Lay-up. This technique provides the high glass/resin ratio that gives high strength. Labor cost is high but can be offset by low-cost molds.* (Du Verre Inc)

5 Spray-up

3-PART HOUSING *encloses drive mechanism for repair truck boom. Broad contours like this are well-suited to Spray-up process. Rough surface away from mold (inner surface here) is one problem with this technique, however.* (Fiberglass Products Engineering Co)

6 Contour Weaving

MISSILE NOSECONE *has several layers of reinforcement, each woven as a one-piece "sock." Shape versatility is one advantage, since weaving is not limited to symmetrical items like this. Some high costs remain, because resin is added by hand.* (Raymond De-icer and Engineering Co)

7 Filament Winding

ROCKET-MOTOR CASES *that carry solid propellants show how Filament Winding can place continuous glass reinforcement precisely where needed for maximum strength. Process is limited primarily to convex contours.* (Lamtex Industries Inc)

criteria were applied on estimates of production rates, operator efficiencies, etc.

A close look at these curves reveals several points that bear on the selection of the right FRP process:

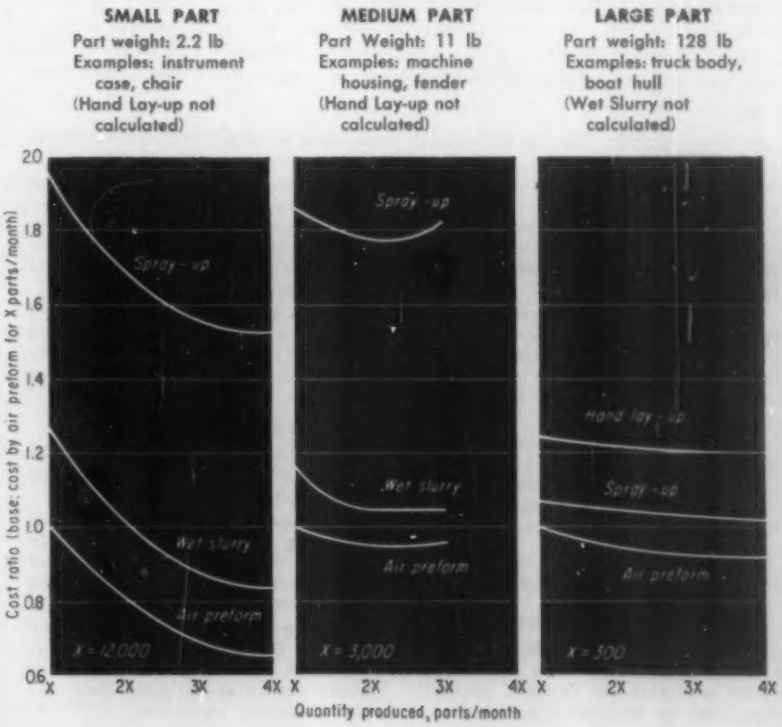
1. . Process choice is more critical for small parts (left-hand curves) than for large ones (right-hand curves), because cost spread (material, direct labor, and overhead) is much greater. The Air Preform process is very efficient for small parts; Spray-up process is least efficient because of higher number of manual operations.

2. . Air Preform process is least affected by size of part and is cheapest process for all sizes considered here. Note that Spray-up costs drop to about 10% above Air Preform for the largest part. Spray-up and Hand Lay-up may become cheaper when size increases beyond the capacity of the largest Air Preform plenum chambers or directed-fiber screens.

3. . Wet Slurry, a relatively new process, shows good potential for all but the largest parts. Note that costs are only about 20% higher than for Air Preform on same-size parts. This spread should narrow as Wet Slurry process is refined, though need to remove water may keep cost per part slightly higher.

4. . Hand Lay-up is the oldest FRP process so, despite lack of mechanization, it can be done fast enough on large parts to stay only 20% higher than Air Preform. This price premium is acceptable to the military, who want the higher glass content possible with the process.

5. . Cost per piece can rise slightly in large quantities after reaching a minimum figure (see medium parts by Spray-up and by Air Preform). This is usually caused by the requirement of an additional press at a certain volume. If maxi-



mum volume for the job does not utilize the new press to full capacity, higher depreciation must be charged and the cost per part swings up slightly.

6. . Spray-up costs are high (except on very large parts) primarily because of higher direct labor required–after spraying, the mix is manually rolled out (replacing the press in other processes). However, expensive metal dies are not required, explaining why Spray-up competes well on smaller-volume jobs and prototyping, despite higher labor cost.

OPEN MOLD VS CLOSED MOLD

The seven basic processes of Table III have been split into two broad groups: those where the part is formed in an open mold (male or female), and those where a male and female die form the part in a closed mold. For open-mold fabrication, the FRP part is usually large and the molds themselves tend to be simply constructed since production quantities are most often low (an exception is filament winding). When quantity of parts is high enough to cover the cost of polished steel molds and presses, the faster closed-mold process–called matched metal-die molding–is most economical.

Matched Metal-die Molding

In this process, chopped strands of glass are first formed into a thick blanket of strands and binder to match configuration of the mold. Two of the three closed-mold techniques shown in Table I–Air Preform and Wet Slurry–incorporate matched metal-die molding as the last step, but use different methods to preshape the blanket, or preform. When fairly flat parts are made, a chopped strand mat or cloth may be used in place of the preform.

After the glass has been prepared, in the form of a preform or simply a mat, measured quantities of resin mix is poured on top. The mix consists of polyester resin, catalyst, pigment, and filler. Fillers reduce cost and shrinkage, and improve weathering and electrical properties. A thin veil of surfacing mat is sometimes applied to give an improved surface finish to the part.

Matched metal-die molding gets its speed from the specially designed presses whose hydraulic systems provide fast travel during opening and closing of the molds over most of the cycle. During final part of the stroke, the control system closes the mold slowly to prevent tearing the preform and to distribute the resin evenly. Parts are cured at 225-250 F, the length of time in the heated molds depending on part thickness. Normally, 15 to 25 parts are obtained per press hour. Trimming occurs as the part is molded, with cutoffs around the mold periphery–but the edge of the finished part usually requires light sanding to improve appearance. Preforms made by Wet Slurry are an exception here, as they fit the mold exactly and do not require trimming of excess material.

Open-mold Processes

When the fabricating technique does not involve a matching mold to distribute the resin and maintain uniform thickness of the part, these operations are usually performed by hand–with brush, spray gun, squeegee, or roller. Curing is in air or in an oven. A flexible matching mold is used in certain specialty processes where better uniformity of thickness or higher glass content is desired than is possible with hand processing, but where matched metal molds are not feasible because of part shape, time or cost. Flexible matching molds can be made by pressing a resilient "blanket" against the single rigid mold supporting the preform and resin. Three methods are commonly employed to create such a resilient blanket: a pressurized plastic bag, a soft rubber plunger, and atmospheric pressure acting on an evacuated plastic bag surrounding the part. A variant of Pressure Bag Molding is Autoclave Molding, where air pressure is replaced by steam–the advantage being higher pressure and a simple source of heat for curing. All four of these specialty open-mold processes have restrictions (Table II) for commercial production.

EDITOR'S NOTE: Each of the seven basic FRP processes will be treated in detail in our continuing series on designing for reinforced plastics. Two of these articles are listed below. Look for up-to-the-minute articles on the remaining five processes in forthcoming issues:

Design Must Be Different for Polyester Premix Molded Parts, Oct 12 '59, p 86. They can take the place of metals in many applications, but design follows different rules than for unreinforced plastics.

Filament Winding Grows Up, July 20 '59, p 46. After several successful years in the aircraft industry, this high-speed process is ready for more work. Article gives design rules.

Besides those two, see these other articles on FRP design problems.

DESIGN ANALYSIS

Flat Reinforced-plastic Springs, Nov 9 '59, p 74—Directionally reinforced epoxy laminates can be more efficient than steel for leaf-spring applications. Here's why, along with critical stress equations and a sample problem.

Glass-fiber Sleeve-springs for High Energy Absorption, Aug 17 '59, p 60—How to design a new kind of spring that can absorb almost five times the impact kinetic energy normally handled by equivalent steel springs.

Stresses in Adhesive Joints, July 7 '58, p 64—Author of book on adhesive bonding of reinforced plastics presents hard-to-find equations for analyzing stresses in joints.

MATERIALS SELECTION

What Fillers Will Do for the Latest Teflon, Sep 28 '59, p 52—Latest design data on filled Teflon 100X.

Three New Epoxies Join the Pre-preg Laminates, Aug 31 '59, p 38—Recently developed resins series combines good high-temperature performance with long shelf life.

Selecting Plastic Laminates for Punching, Feb 2 '59, p 57—Ready-reference chart relates punching ease of various laminates to their electrical and mechanical properties.

Resins for Reinforced Plastics, May '56, p 203—Five major classes of resins evaluated for processing characteristics, mechanical and electrical properties, appearanace, cost.

MATERIALS TESTING

More Work for High-temperature Reinforced Plastics, Nov 23 '59, p 58—data on FRP at ultrahigh temperatures are accumulating rapidly. Article tells how data reveal fundamental behavior of these materials, and shows how new theories of thermal protection are emerging.

Fiber-reinforced Plastics, Feb 3 '58, p 69—How 14 organizations have formed a team to set reliability standards for FRP. Five experiments cover 6 variables, with Graeco-Latin square analysis to make each test count.

Creep of Reinforced Plastics, Mid-Oct '56, p C-22—Tests compare 8 fiber-resin combinations up to 500 F.

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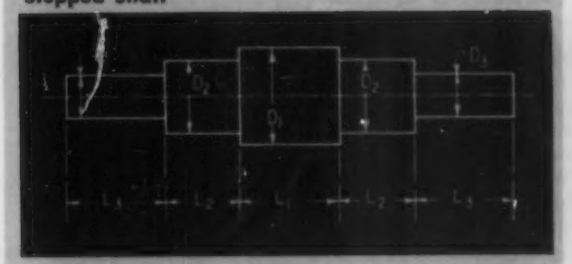
fast equations give

CRITICAL FREQUENCY OF STEPPED SHAFTS

HERBERT K SACHS, *associate professor*
Engineering Mechanics Dept
Wayne State University, Detroit

Stepped Shaft



And if the shaft has some other kind of cross-sectional nonuniformity, you just "translate" it into a stepped shaft, for purposes of calculation. The author's equations require only simple algebra—a welcome contrast to working with differentials, yet give answers with reasonable accuracy.

Here is a time-saving way to find the natural frequency and critical speed of stepped shafts or beams for a variety of cross-sections. From four sets of equations, you simply select the set that most closely fits contour of the actual shaft, and substitute the necessary dimensions. A tapered round shaft, for example, is divided into a series of round steps—more steps giving higher accuracy. A tapered rectangular shaft is divided into an appropriate number of rectangular steps. For any shape the number of steps needed is no problem—the equations accept any number.

These equations have been developed to avoid complicated mathematical or graphical methods that require trial and error and need 10 to 15 times as much work. Despite their simplicity the equations give fairly accurate results, usually within 3%, provided shaft is symmetrical with respect to the mid-point of the shaft length axis as in the sample problem that follows. A closer answer requires solving as many simultaneous equations as the arbitrary shaft sections you need to represent the actual shaft. This is time consuming, even if high-speed digital computers are used. But even if an iteration method is needed to obtain a more precise answer, the new equations are valuable in reducing the number of passes required.

These equations are particularly useful when designing high-speed rotating equipment—where vibrations can cause noise and ultimate failure. Similar problems are encountered in long drive shafts and engine crankshafts.

The four sets of derived equations shown below give frequency and critical speed for:

- Uniform round shafts
- Round stepped shafts
- Tubular stepped shafts
- Rectangular stepped shafts.

Once an actual shaft is transformed into a stepped shaft, the applicable equations give the solution directly.

These equations are derived from the basic equation:

$$\omega_n = a_n \sqrt{\frac{EI}{\mu L}}$$

which gives the vibration frequency of symmetrical shafts of constant cross-section, with known end conditions represented by the coefficient, a_n. From this equation it can be seen that, for shafts of nonuniform cross-section, I and μ are functions of the shaft length. By assuming sinusoidal deflection and simplifying the resulting differential equations, an equivalent ratio I/μ can be expressed in dimensional terms. Since a true sine curve is applicable only to a shaft of uniform cross-section, any deviation from uniformity will result in a different deflection curve. In a practical sense, this means that accuracy of results will depend on how nearly the deflection of the assumed stepped shaft represents that of a uniform cross section shaft.

SAMPLE PROBLEM

Determine the natural frequency of a shaft with circular but differing cross-sections that are symmetrical about its midpoint (see diagram above). Dimensions are:

$L_1 = 24$ in. $\quad D_1 = 10$ in.
$L_2 = 12$ in. $\quad D_2 = 7\frac{1}{2}$ in.
$L_3 = 12$ in. $\quad D_3 = 5$ in.

There is no need to assume steps here; this problem fits directly into the set of equations for Round Stepped Shaft. The critical frequency, then, is:

$$\omega_n = \frac{\pi^2}{4\sqrt{\frac{.283}{30 \cdot 10^6 \cdot 386}\left[\frac{24}{\sqrt{10}} + 2\,\frac{12}{\sqrt{7.5}} + 2\,\frac{12}{\sqrt{5}}\right]^2}}$$

$= 683$ RAD./SEC

For same shaft with "built-in" end supports

$\omega_n = 4 \times 683 = 2732$

This is the same sample problem calculated by the Holzer method on page 158 of Den Hartog's *Mechanical Vibrations*. The answer there is:

$\omega_n = 700$

$700 - 683 = 17$

$\frac{17}{700} \times 100 = 2.4\%$ difference between methods

(Continued on next page)

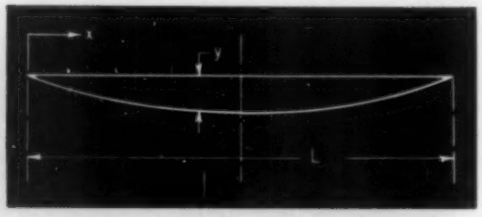
REPRINTED circle P27, inside back cover

Derivation of Equations

It is known that a torsional shaft of variable cross-section can be represented by one with uniform cross-section, called the ideal or equivalent shaft, if the fundamental frequency of both is identical. This requires torsional rigidity of the equivalent to equal that of the actual shaft. But for any given cross-section the torsional stiffness depends only on the shaft length. The equivalent length of the ideal shaft is therefore determined by cross-section and length of the actual shaft. This principle is employed in the four expressions for critical speed. In these expressions the summation of the terms in the brackets denotes "equivalent length" of the ideal shaft of unit thickness.

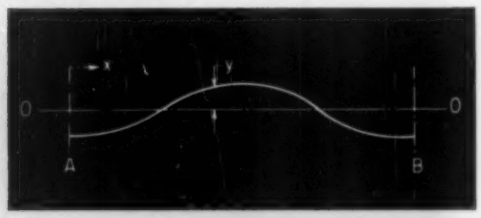
In flexural vibrations the displacement curve differs from that in torsion. For a simply supported shaft these displacements occur in form of sine waves. Assuming that the dynamic deflection curve of a variable cross-section shaft approaches a half wave of a sine curve in its lowest mode (below), replace this shaft with one of uniform cross-section.

Half Sine Wave



Length of the substitute is to be such that its fundamental frequency is identical with actual shaft frequency. For shafts which have "built-in" end-supports, a full sine wave (below) represents the elastic displacement curve, and all critical speeds given in the equations are to be multiplied by four.

Full Sine Wave



For a stepped shaft (see sample problem) with a sinusoidal elastic curve, the differential equations are:

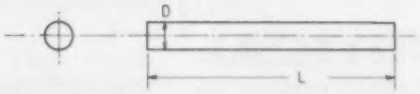
$$\begin{aligned} EI_1Y_1'''' &= -\mu_1\ddot{Y}_1 \\ EI_2Y_2'''' &= -\mu_2\ddot{Y}_2 \\ EI_3Y_3'''' &= -\mu_3\ddot{Y}_3 \\ EI_4Y_4'''' &= -\mu_4\ddot{Y}_4 \end{aligned} \qquad (1)$$

These are fourth-order partial differential equations where the primes above each first Y denote differentiation with respect to length and the pair of dots above each second Y denote differentiation with respect to time. Obtain solutions satisfying (1):

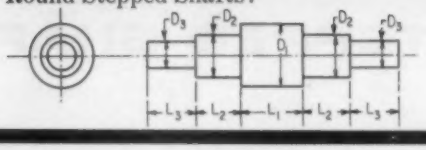
$$\begin{aligned} Y_1 &= C_1 \sin(a_1x)\sin(\omega t) \\ Y_2 &= C_2 \sin(a_2x)\sin(\omega t) \\ Y_3 &= C_3 \sin(a_3x)\sin(\omega t) \\ Y_4 &= C_4 \sin(a_4x)\sin(\omega t) \end{aligned} \qquad (2)$$

THESE EQUATIONS

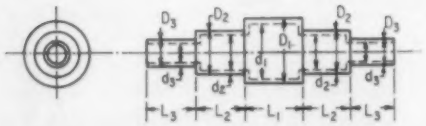
Uniform Round Shafts:



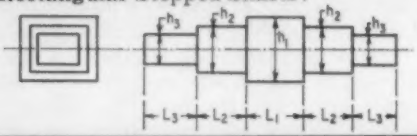
Round Stepped Shafts:



Tubular Stepped Shafts:



Rectangular Stepped Shafts:



SYMBOLS: A = Area of cross-section, in.²
ω_n = Circular frequency
E = Young's Modulus (for steel = 30×10^6)
I = Moment of Inertia
μ = Mass/unit length
L = Shaft length

By substituting values obtained in (2) into (1):

$$\begin{aligned} EI_1a_1^4 &= \mu_1\omega_n^2 \\ EI_2a_2^4 &= \mu_2\omega_n^2 \\ EI_3a_3^4 &= \mu_3\omega_n^2 \\ EI_4a_4^4 &= \mu_4\omega_n^2 \end{aligned} \qquad (3)$$

or by transposing:

$$\omega_n^2 = \frac{EI_1a_1^4}{\mu_1} = \frac{EI_2a_2^4}{\mu_2} = \frac{EI_3a_3^4}{\mu_3} = \frac{EI_4a_4^4}{\mu_4} = \cdots \frac{EI_na_n^4}{\mu_n} \qquad (4)$$

Since $aL = \pi$ for a shaft of constant cross-section, then for stepped shaft

$$(a_1L_1 + a_2L_2 + a_3L_3 + a_4L_4) = \pi \qquad (4a)$$

Substituting this in the preceding equations:

$$\sqrt{\omega_n}\left[L_1\sqrt[4]{\frac{\mu_1}{EI_1}} + L_2\sqrt[4]{\frac{\mu_2}{EI_2}} + L_3\sqrt[4]{\frac{\mu_3}{EI_3}} + L_4\sqrt[4]{\frac{\mu_4}{EI_4}}\right] = \pi \qquad (5)$$

If μ_1 and I_1 are based on a circular shaft of unit diameter such that for a stepped shaft,

$$\begin{aligned} I_e &= \pi/64 \quad (1)^3 \quad \text{(equivalent shaft)} \\ A_e &= \pi/4 \quad (1)^2 \quad \text{(equivalent shaft)} \end{aligned}$$

the roots a_1, a_2, a_3, a_4 . . . a_n can be expressed in terms of

SIMPLIFY SHAFT PROBLEMS

The derived equations: **Frequency, rad/sec . . .** **Critical speed, rpm**

$$\omega_n = \frac{\pi^2 D}{4\sqrt{\frac{\gamma}{Eg}}\,L^2} \qquad n = \frac{4{,}686{,}000\,D}{L^2}$$

$$\omega_n = \frac{\pi^2}{4\sqrt{\frac{\gamma}{Eg}}\left|\frac{L_1}{\sqrt{D_1}}+\frac{L_2}{\sqrt{D_2}}+\frac{L_3}{\sqrt{D_3}}+\frac{L_4}{\sqrt{D_4}}+\cdots\frac{L_n}{\sqrt{D_n}}\right|^2} \qquad n = \frac{4{,}686{,}000}{\left|\frac{L_1}{\sqrt{D_1}}+\frac{L_2}{\sqrt{D_2}}+\frac{L_3}{\sqrt{D_3}}+\frac{L_4}{\sqrt{D_4}}+\cdots\frac{L_n}{\sqrt{D_n}}\right|^2}$$

$$\omega_n = \frac{\pi^2}{4\sqrt{\frac{\gamma}{Eg}}\left|\frac{L_1}{\sqrt{D_1^2+d_1^2}}+\frac{L_2}{\sqrt{D_2^2+d_2^2}}+\frac{L_3}{\sqrt{D_3^2+d_3^2}}+\frac{L_4}{\sqrt{D_4^2+d_4^2}}+\cdots\frac{L_n}{\sqrt{D_n^2+d_n^2}}\right|^2} \qquad n = \frac{4{,}686{,}000}{\left|\frac{L_1}{\sqrt[4]{D_1^2+d_1^2}}+\frac{L_2}{\sqrt[4]{D_2^2+d_2^2}}+\frac{L_3}{\sqrt[4]{D_3^2+d_3^2}}+\frac{L_4}{\sqrt[4]{D_4^2+d_4^2}}+\cdots\frac{L_n}{\sqrt[4]{D_n^2+d_n^2}}\right|^2}$$

$$\omega_n = \frac{\pi^2}{\sqrt{\frac{12\gamma}{Eg}}\left|\frac{L_1}{\sqrt{h_1}}+\frac{L_2}{\sqrt{h_2}}+\frac{L_3}{\sqrt{h_3}}+\frac{L_4}{\sqrt{h_4}}+\cdots\frac{L_n}{\sqrt{h_n}}\right|^2} \qquad n = \frac{4{,}050{,}000}{\left|\frac{L_1}{\sqrt{h_1}}+\frac{L_2}{\sqrt{h_2}}+\frac{L_3}{\sqrt{h_3}}+\frac{L_4}{\sqrt{h_4}}+\cdots\frac{L_n}{\sqrt{h_n}}\right|^2}$$

D = Diameter of shaft
g = Gravity constant (386 in./sec)
h = Height of rectangular section
γ = Specific weight lb/in. (0.283 lb/in. for steel)
n = critical speed, rpm
a_n = coefficient, depending on type of support

a, and their respective diameters, D_1, D_2, D_3 . . . D_n. Hence from (4):

$$a_1 = a_s\frac{1}{\sqrt{D_1}}, \quad a_2 = a_s\frac{1}{\sqrt{D_2}}, \quad a_3 = a_s\frac{1}{\sqrt{D_3}}, \quad a_4 = a_s\frac{1}{\sqrt{D_4}}$$

Substituting above expressions for a_1, a_2, a_3, a_4, into (4a):

$$a_s\left(\frac{L_1}{\sqrt{D_1}}+\frac{L_2}{\sqrt{D_2}}+\frac{L_3}{\sqrt{D_3}}+\frac{L_4}{\sqrt{D_4}}\right) = \pi \qquad (6)$$

Then, substitute $a_s = 2 \cdot 4\sqrt{\frac{\gamma}{Eg}}\sqrt{\ }$ and solve for ω_n in (6). The equations shown above for **round stepped shafts** are the result. For **uniform round shafts**, $D_1 = D_2 = D_3 = D_4 = D$ and $L_1 = L_2 = L_3 = L_4 = L$, resulting in simplified equations shown above.

The concept of equation for **round shafts is** also useful for shafts consisting of tubular sections or any arbitrary but symmetrical cross-sections. Since **the mass for tubular sections** is proportional to $(D^2 - d^2)$, which is the difference of outer and inner diameter squared, and moment of inertia is proportional to $(D^4 - d^4)$, it follows:

$$\alpha^4 = \frac{\mu\omega^2}{EI} = C\,\frac{D^2 - d^2}{D^4 - d^4} = C\,\frac{1}{D^2 + d^2}$$

Taking the fourth root of the expression above and substituting in equation for critical speed for round stepped shafts results in equation for critical speed and frequency for tubular sections.

Similarly, where h represents the minimum height of a rectangular cross-section, the equations for frequency and critical speed shown above are the result.

For REPRINT of above article, just check P27 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For additional information on beams and speed-torque problems see:

"Speed-torque Analysis for Rotating Mechanical Systems," Dec '56, p 184. First part gives method for solving speed and torque equations in an "ideal" rotating system. Second part, in Feb '57 issue, extends method to the effects of inertia, compliance and friction.

"Conjugate Beam Method," Aug 18 '58, p 83, gives 4 examples of application to load problems.

A Dozen Jobs for LOW-MELTING-POINT ALLOYS

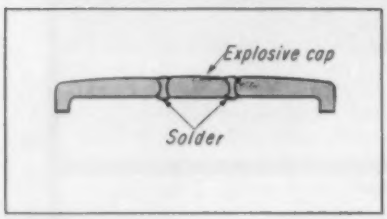
Included here are such design applications as special soldering, imbedding, glass-to-glass sealing, adjusting, casting and encapsulating.

PETER C NOY, *production engineer*
Canadian General Electric Co, Barrie, Ont

Most low-melting-point alloys contain bismuth. It has the interesting property of forming alloys that have either sharp melting points or slush phases, and do their melting at relatively low temperatures. Bismuth (like antimony) also expands on solidification.

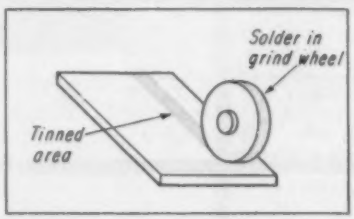
Wood's Metal, Rose's Metal, and Newton's Alloy are some old names for a class of alloys now available with a wide range of properties developed for new applications. These newer alloys start at a melting point of 117 F.

Most bismuth alloys cannot be kept at temperatures much above their melting points, because they volatize and oxidize selectivity. With tensile strengths of, generally, 6000 psi, they are not strong, but some special alloys withstand 13000 psi. They are poor conductors of electricity and are subject to shrinkage upon aging. Their exclusive properties, however, can be put to work in many ways—here are 12 of them.



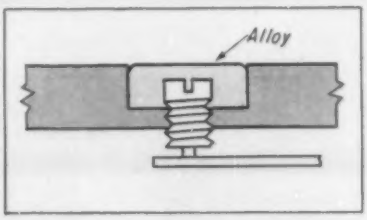
1

LOW-TEMPERATURE SOLDER
Where the temperature of molten lead-tin solder would be hazardous, bismuth alloys solve the problem. Examples: Solder-sealing of artilley-shell fuse; soldering fusible links themselves, where heat would ruin adjacent components. Steel, copper, brass parts must be "tinned" first, unless they are already tin plated.



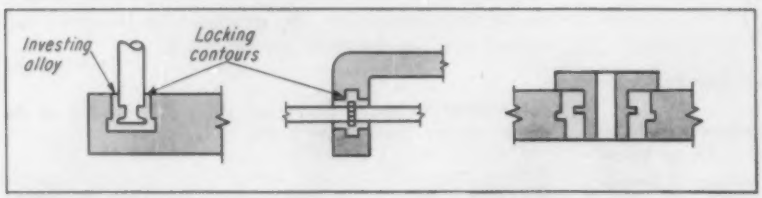
2

SOLDER FOR PASSIVE METALS
Titanium, tantalum, niobium and other difficult-to-solder metals, besides glass and ceramics, can be tinned by grinding with a wheel loaded with low-temperature alloy. Under conditions of properly controlled speed this technique will wet the surface, after which ordinary solders and techniques are used.



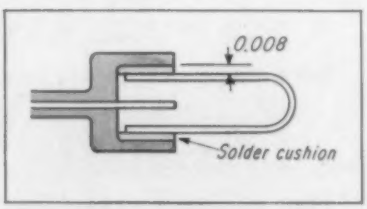
3

SEALING ADJUSTABLE DEVICES
Unauthorized and undesirable tampering can be discouraged with alloy seals. When proper adjustment is necessary, alloy may be melted out easily.



4

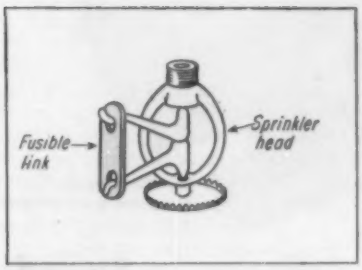
IMBEDDING MACHINE PARTS
Accurate alignment and strong attachment of machine parts can be obtained with an investment. Studs, rods, shafts, bushings and grommets normally press-fit into closely machined holes may be economically and exactly set with these alloys. The investing alloy will not wet the parts, so locking contours must be provided.



5

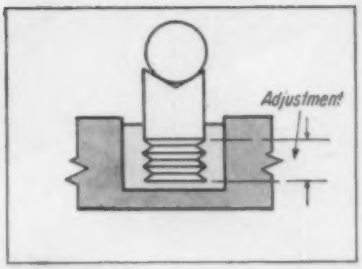
SEALING GLASS
For sealing glass to glass, or glass to solderable metal, choose an alloy of tin and iridium, melting at about 250 F. It will also adhere to ceramics and quartz. Low vapor pressure makes this seal ideal for vacuum tubes and other apparatus. Also, the cushion of solder that separates components absorbs thermal expansion differences that otherwise make trouble.

DESIGN FILE



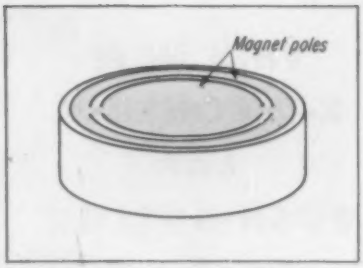
6

FUSIBLE LINK FOR ACTIVATION
This is perhaps the oldest and most familiar application. Fusible link melts to start mechanical action at a high limit (as in firefighting sprinkler shown), or molten "link" freeze to stop action at a low limit, as in process control systems.



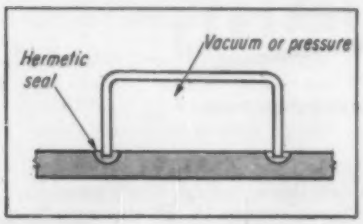
7

POSITIVE, INFREQUENT ADJUSTMENT
Where adjustment of plungers, wheels, jig members, and calibrating features is required at infrequent intervals, low-melting alloys allow adjustment when melted; provide positive locking when solidified.



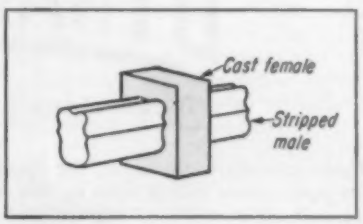
8

MAGNET HOLDERS
Because of their outstanding diamagnetic properties, alloys high in bismuth are ideal for holding magnets in magnetic chucks and other devices.



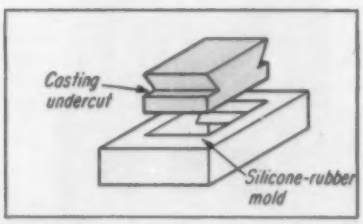
9

CHAMBER SEALANT
Low-melting alloys are superior to mercury for sealing vessels under conditions of slight vacuum or pressure. Low vapor pressure of alloy prevents contamination of vessel atmosphere, and is more convenient and safer than mercury.



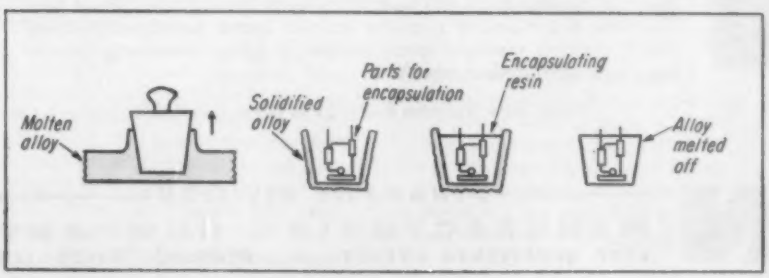
10

CAST COMPONENTS
Close-tolerance bores, for oddly shaped parts and reciprocating members, can be made by coating the member with strippable electroplate, or carbon from a smoky flame, and then casting other member to it. When stripped the male member will be a close fit in the female.



11

SHORT RUNS, MODELS, PROTOTYPES
Rubberlike molds, easily made from castable, room-temperature-curing silicones, are flexible enough to release deeply undercut shapes, and heat-resistant enough to withstand molten alloy below 600 F. Alloy expands on cooling, is ideal for precision casting of patterns and prototypes.



12

ENCAPSULATING
Encapsulating-molds for electronic components are produced by dipping steel master in molten alloy which produces a slush-cast female mold. This holds the components and encapsulating compound until the latter is cured. Alloy is easily melted off the cured encapsulation.

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SIGNIFICANT COMPONENTS MATERIALS, PROCESSES

Miniature shutoff valve . . .

for vacuum or pressure service features an O-ring on cylindrical face of straight plug, which prevents leakage past inlet port as well as stem area. Handle is color-coded for gas or liquid service; handle position indicates exact valve position. Quarter turn changes position from full-open to dead-tight close. No spring is used. Available in brass or stainless 303 with male or female connections in ¼ or ⅜ in. size. Typical applications include instrumentation, inert-gas test stands, hydraulic clamps and jacks **Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena, Calif.**

Circle 300 on Reader Service Card

Subminiature pressure switch

has pressure-setting adjustment. For service up to 200 psi, under vibration, shock and acceleration test conditions. Volume of switch is less than 1 cu in.; weighs slightly over 1 oz. Press capsule and snap-action switch are contained in all stainless steel housing. For electrical switching in response to pressure changes in gas or liquid. **Bristol Co, Waterbury 20, Conn.**

Circle 301 on Reader Service Card

Temperature controller . . .

is said to control within ±1°, up to 600 F. Stainless steel sensing element is small bullet-probe, 1 x ¼ in. dia. By using light-gage twisted lead wire, pre-aged thermistor probe may be located in platens, in air ducts and in immersion wells up to 100 ft away from amplifier-relay cabinet. Loads up to 10 kw can be controlled directly without separate magnetic contactor. May be used on 120, 208 or 240 v; 60 cps. Scale covers dual-range, from 25 to 225 F or 200 to 600 F. Dial-plate control is removable from amplifier-relay for remote location up to 30 ft away. Basic unit lists for $84.50. **Edwin L Wiegand Co, 7500 Thomas Blvd, Pittsburgh 8.**

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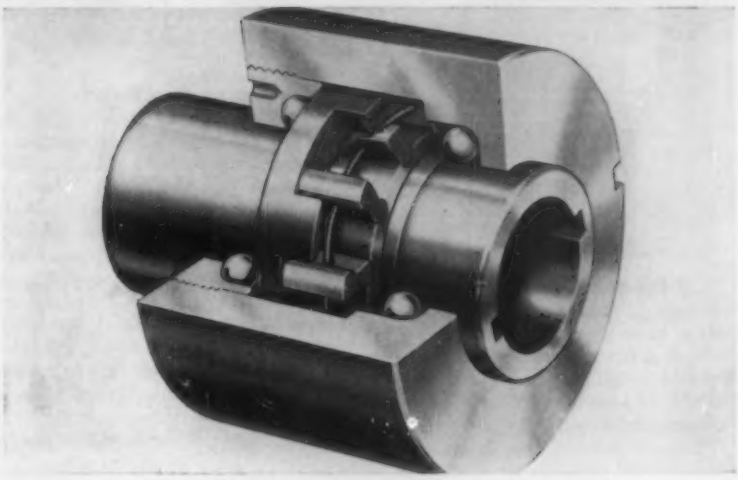


Feedback locking and positioning control . . .

transmits driving torque and rotates freely in either direction from input to output shaft. Will not permit independent motion of output shaft or transmit feedback torque or rotation from output shaft back to input shaft. If output shaft becomes fixed member, outer race can rotate freely in one direction and become locked in opposite direction, or vice versa, by proper positioning of input shaft. Consists of outer race, input shaft with control elements, output shaft, two sets of opposing sprags and energizing means for both sets of sprags. Method of mounting determines function as no-back or automatic feedback locking or positioning device or two-directional overrunning clutch. Suitable for high-speed overrunning, such as 2800 rpm for model with 1 in. bore. Sizes for shafts from ⅞ to 2¼ in. with rated holding outputs of 72 to 30,000 in.-lb. **Formsprag Co, 23617 Hoover Rd, Warren, Mich.**

Circle 303 on Reader Service Card

Static inverter-converter . . .

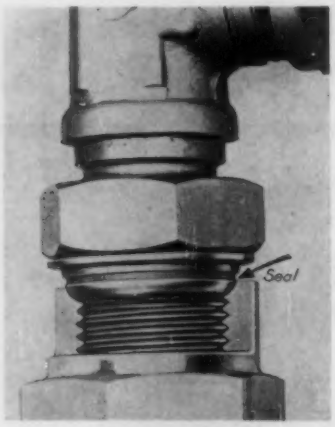
supply operates from self-contained, 28-v-dc, silver-cadmium battery and provides regulated multiple outputs of 200 or 115 v, 3200 cps, three phase at 1 kva; 300 v dc at 0.5 amp and 150 v dc at 1 amp. Primarily for short operating times, unit produces full output (total 1300 va for 4 min.). May be operated continuously with external cooling or intermittently with thermal recycle rate of 1 min. on, 4 min. off at 122 F. Recycling feature is possible because of thermodynamically reversible heat sink, in which an exotic solid-to-liquid coolant produces a delay in temperature rise. Inverter-converter is reported to provide good voltage regulation inherently and to be stable in frequency and phase. Construction meets pertinent MIL specifications. Unitized for ease of assembly. Subassembly channels in three-phase portion of supply are interchangeable. Entire unit, including battery, is hermetically sealed. Applicable where high power for short periods is required. **Magnetic Amplifiers Inc, 632 Tinton Ave, New York 55.**

Circle 304 on Reader Service Card

Wound-wire porous metal . . .

for filtration and non-filtration applications, is wound by high-precision winding process into hollow cylinders or cones. Cylinders are cut once axially, opened and flattened for forming special shapes. Designed for mildly corrosive conditions and temperatures up to 400 F. Wound wires are bonded with silver or copper braze at all contact points in continuous, controlled atmosphere furnaces. Can be made from most metals that can be drawn into fine wire. Pore size range is from 2 to 1000 microns or more. **Bendix Filter Div, Bendix Aviation Corp, 434 W 12 Mile Rd, Madison Heights, Mich.**

Circle 305 on Reader Service Card



Seal for tube fitting . . .

for high temperature and corrosive conditions provides metal-to-metal seal with locknut at joint. Adaptable to AND 10050 ports by remachining gasket section. Permits 360° positioning of fitting, without loosening by vibration or thermal shock. Withstands pressures from 28 in. vacuum through 5000 psi under temperature variations from —270 through 1200 F. Made in sizes from ¼ through 2 in. OD tube of aircraft quality type 321 stainless steel. **Paragon Mfg Corp, 1179 E 134th St, Cleveland 10.**

Circle 306 on Reader Service Card

Flexible metal connectors . . .

for pump installations, hot water systems and steam systems where thermal expansion and vibration are problems. Tests show they can correct pipe misalignment, and also serve as connectors to absorb pipe expansion and on pumps where vibration of unit must be dampened to prevent unwanted noise and vibration being transmitted along lines to other parts of building. Available in bronze in ¼ to 4 in. ID and in stainless steel in 5 to 12 in. ID sizes. Connectors withstand pressures from 125 to 600 psi, varying with tube ID and material of construction. **Pennsylvania Flexible Metallic Tubing Co, 7200 Powers Lane, Philadelphia.**

Circle 307 on Reader Service Card

Measures and controls temperature . . .

of moving or stationary objects without physical contact by detecting thermal radiation emitted by objects. Radiation is translated into signal voltage, which is amplified to level sufficient to drive indicator calibrated directly in temperature. Sensitivity is high (7 F at 2000 F) and instrument response is said to be rapid. Infrared sensing element is hermetically sealed within optical head. Standard range is from 400 to 2000 F. Reported to be unaffected by ambient temperature variations from 20 to 120 F. Available with indicators or recording potentiometers. **Radiation Electronics Co, 5600 W Jarvis Ave, Chicago 48.**

Circle 308 on Reader Service Card

Servomotor gearheads . . .

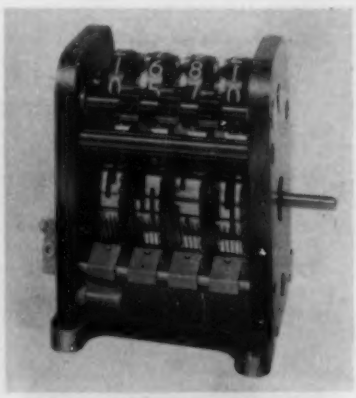
in planetary units are available with ratios up to 2500:1 with torque rating of 25 in.-oz and max backlash of 10 min. Overall length is 0.800 in. Spur units are offered with ratios to 4000:1. Low-ratio series, to 37:1, offers over-all lengths of 0.500 in. for torque rating of 25 in.-oz and 0.609 in. for torque rating of 50 in.-oz. Max backlash is 15 min. All units with ratios of 38:1 up to 4000:1 have torque ratings of 50 in.-oz and max backlash of 30 min. Guaranteed for 2000 hr operating life. **US Gear Corp, 81 Bay State Rd, Wakefield, Mass.**

Circle 309 on Reader Service Card

Fast-grab adhesive . . .

for general-purpose bonding is also said to have long open-bonding time. Suitable for brush, spray or roll coat application for bonding fabrics, leathers and insulation to woods, metals and glass. High-solids red adhesive has reclaimed rubber base and is supplied in 1 qt, 1 gal and 55 gal quantities. Conforms to requirements of MIL-A-101A. **Schwartz Chemical Co Inc, 50-01 Second St, Long Island City 1, NY.**

Circle 310 on Reader Service Card



Direct-reading counter . . .

provides simultaneous readouts in visual and digital form. Analog-to-digital converter can transmit coded signals to remote locations for use as input to computers, business machines, digital printers, servomechanisms, integrators and meters. Shaft is rotated by temperature-controlled servo and, when scale factors are selected that enable unit's full range to equal 100 C, it provides both visual and electrical readouts to nearest 0.01 C. Operates in temperatures of —80 to 350 F. Vibration range is 5 to 50 cps at 10 g. Input driving torque is 2 in.-oz. Operates to 250 rpm max. **Kearfott Co Inc, Little Falls, NJ.**

Circle 311 on Reader Service Card

Collector ring avoids arcing

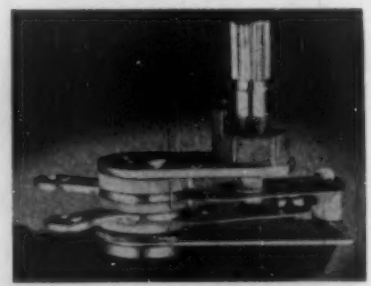
by employing microswitch to interrupt power. Ring opens circuit at one position of shaft. Elimination of arcing is said to increase life of ring. In one model positioning can be controlled within 2°. **B A Wesche Electric Co, 9027 Shell Rd, Cincinnati 36.**

Circle 312 on Reader Service Card

Motor protection relay . . .

allows operator 5 to 10 min. to remove trouble in range of min pickup to 175% of tap value setting; gives normal time delay tripping protection for medium overloads; and provides instantaneous tripping on heavy fault current. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 313 on Reader Service Card



Positive-off thermostat . . .

permits cut-out of thermostatic control through manual operation of adjusting stem. Provides positive make-break control of electrical circuits in response to temperature changes. Restricting device providing off feature can be used either to cut out thermostatic control or to limit lower range of operation of thermostat. Operates over temperature range of 0 to 650 F and is rated 15 amp on 115 v ac; 10 amp on 230 v ac. Suitable for use with appliances, heating and ventilating equipment, vending machines and manufacturing machinery. **Norwalk Thermostat Co, 52A Woodlawn Ave N, Norwalk, Ohio.**

Circle 314 on Reader Service Card

Audible alarm device . . .

is transistor-equipped and creates any of several available sounds, which can be changed by substituting plug-in cards. Vol-

(continued on page 66)

DU PONT IMPROVES

VITON®

SYNTHETIC RUBBER

- NOW GIVES TWICE THE SERVICE LIFE AT 600°F.
- OFFERS GREATER RESISTANCE TO CHEMICALS AND SOLVENTS

VITON's remarkable resistance to heat and fluids has already improved performance of components for appliances, autos, aircraft and many types of industrial equipment. Now the ability of this new synthetic rubber to withstand heat and chemical exposure has been extended to even greater limits. Here are some of the properties of the new high-performance grade, now commercially available in a wide range of products.

Improved resistance to heat aging—When oven-aged in air at 400° F. or less, VITON vulcanizates now remain usefully elastic for *indefinite periods*. At higher temperatures, they can be expected to remain usefully elastic for more than:

3000 HOURS @ 450° F.
1000 HOURS @ 500° F.
240 HOURS @ 550° F.
48 HOURS @ 600° F.

Improved resistance to fluid exposure—VITON now has better resistance to nitric acid, glacial acetic acid and hydrochloric acid, as well as to certain aromatics and diester lubricants. Its proven resistance to a wide variety of oils, solvents, fuels and chemicals remains unequalled among synthetic rubbers.

Complete information—Learn more about VITON, and how it can improve the products you make and use. Technical literature just published will give you all the facts. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. PE-1, Wilmington 98, Del.

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SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

OTHER IMPORTANT PROPERTIES OF VITON

Hardness: 60 to 95 durometer on the Shore A scale.

Tensile strength: 2000 to 3000 psi. at room temperature, with elongation from 100% to 400%, depending on hardness; at 300° F., tensiles of 300 to 1000 psi., with elongation from 80% to 200%.

Compression set: VITON vulcanizates recover to within 90% to 97% of original dimensions when compressed 25% and held at 250° F. for 70 hours.

Low temperatures: Specimens 0.075 in. thick have a Young's modulus of 10,000 psi. at −20° F. and a brittle point of −47° F. A 0.010 in. thick coating of VITON on wire did not crack at −90° F., when bent around a mandrel 10 times the diameter of the wire.

Ozone and weather: VITON has withstood 28 days in 100 ppm of ozone, without a crack! After twelve months' exposure to direct Florida sunlight, it still remained in perfect condition.

Electrical: Typical values—DC resistivity of 1.4×10^{14} ohm-cm; specific inductive capacity of 8.53; power factor of 2.5%; dielectric strength of 412 volts/mil.

why
Edgewater rolled steel rings
are best . . .
A solid steel block is heated to forging temperature, and thoroughly soaked.
The block is upset on a forging press, and the center is punched out.
On the rolling mill, the heated punched block revolves between main and pressure rolls, where its diameter grows and section shape is formed. Edging rolls control width.
Below—representative sections of rings rolled by Edgewater.

From a solid block of steel, a solid ring has been formed, to required size and shape. The accuracy possible with this process greatly minimizes the need for further finishing. Diameters are from 5 to 145 inches, weights up to 14,000 pounds. Materials include carbon and alloy steels, stainless, tool steels, titanium. Facilities available for machining and heat treatment.

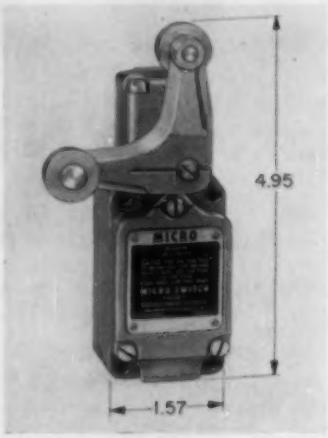
Write for descriptive bulletin.

Edgewater Steel Company

Dept. PE • P.O. Box 478 • Pittsburgh 30, Pa.

ume control is also included. Can be used with most voltages since signal device has no moving electrical parts. Suitable for Class 1 Div 2 applications. **Lundell & Co, PO Box 156, Mount Prospect, Ill.**

Circle 315 on Reader Service Card

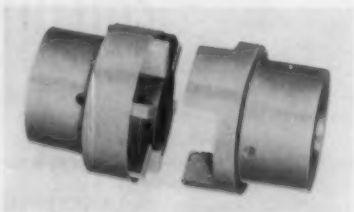


Maintained contact limit . . . switch has yoke type of actuator which may be rotated to any one of four positions, 90° apart. Electrical capacity is 10 amp, 120, 240 or 480 v. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

Circle 316 on Reader Service Card

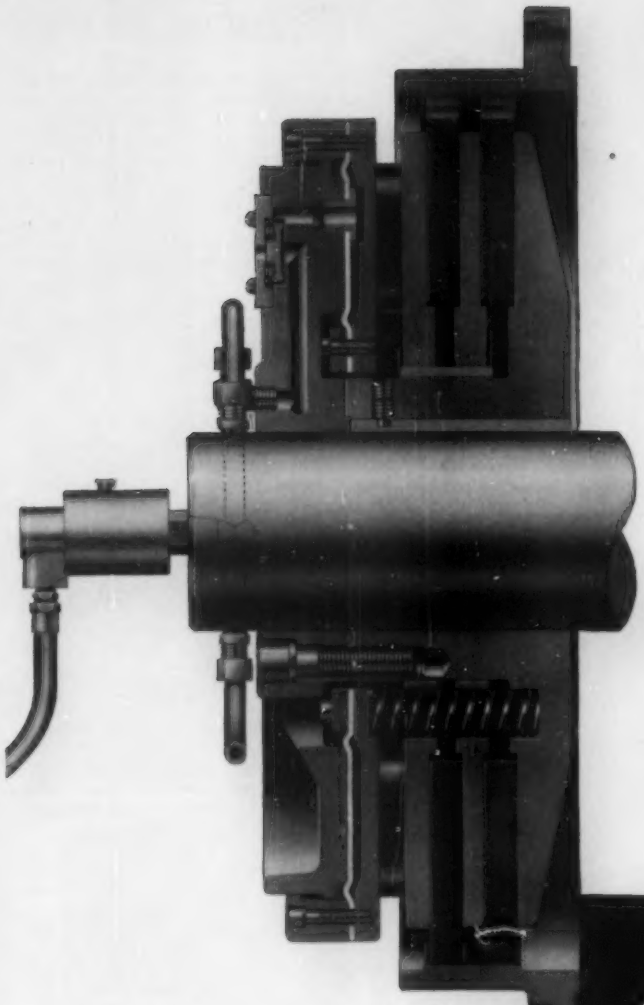
Heavy-duty flexible coupling . . is available in shaft sizes up to 5½ in. dia, for 35 to 700 hp at 1800 rpm. Consists of two metal bodies with interlocking jaws separated by non-metallic load cushions. These cushioning inserts are replaceable without disturbing either driven or driving units. Movable steel collar provides access. **Gerbing Mfg Corp, Elgin, Ill.**

Circle 317 on Reader Service Card



Absolute-pressure switches . . . capable of continuous duty —65 F to 1000 F are for use in areas where adjacent equipment generates abnormal amounts of heat. Used to provide electrical signals at predetermined levels in such media as air, oxygen, steam, hydraulic fluids. Available at any pressure in 20 to 200 psia range, with proof pressures to 375 psia. Accuracy said to be within 10% over full

(continued on page 70)



1. Quickest acting, most responsive air clutch available!
2. Finger tip control!
3. Built-in quick release valves! (Optional)
4. Requires minimum volume of air!
5. No adjustment necessary!
6. Internally ventilated — cooler operation!
7. Operates at air pressures up to 140 psi!
8. Most compact!
9. Interchanges with and can be used to replace Dodge or other mechanical clutches in existing installations.
10. Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.

AIR-GRIP

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of Mishawaka, Ind.

CALL THE TRANSMISSIONEER —your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone book for "Dodge Transmissioneer."

This air clutch, engineered to modern needs, provides maximum torque capacity in minimum space. Its operation requires less air, resulting in amazing sensitivity. It gives the operator split-second control—from "inching" to full engagement. Quick-release valves are built into the clutch itself, as optional equipment, for instant disengagement where such service is required.

The unique design of Air-Grip places the air seal disc at the end *farthest* from the pressure plates, which generate the heat inherent in clutch action. This combined with automatic internal ventilation, insures cooler operation and longer life under severest service. Call your local Dodge Distributor, or write for Bulletin.

DODGE MANUFACTURING CORPORATION, 1200 Union Street, Mishawaka, Indiana

PLASTICS
in Design
Engineering

HOW TO SAVE TIME AND MONEY

Choose Garlock as *the* source for all your plastic needs. They've had years of experience in injection molding, compression molding, extruding, punching, machining, and grinding of stock shapes and intricate parts. "Know-how" like this enables Garlock to recommend and furnish plastic materials *exactly* as you need them . . . without delay and at the lowest possible cost.

Garlock offers a wide selection of shapes and parts—regardless of size, tolerance, or quantity—in these engineered materials:

Teflon† TFE—contains the finest combination of chemical, electrical, and mechanical properties . . . chemically inert, outstanding electrical qualities, low coefficient of friction . . . withstands temperatures as low as −395°F, as high as +500°F.

Nylon—guaranteed bubble-free . . . has high tensile and compressive strength, good resistance to heat and chemicals, solvents, oils and greases, retains toughness at temperatures ranging from −40°F to +350°F.

Polychlorotrifluoroethylene (C.T.F.E.)—colorless, non-flammable . . . offers excellent dielectric properties, high compressive strength, resistance to chemicals, low cold flow in temperatures from −400°F to +390°F.

Teflon FEP—combines the exceptional properties of Teflon with the advantage of being easily melt-processed . . . **Delrin†**—offers metal-like strength and rigidity over a wide temperature range . . . **Polyethylene**—light, flexible, excellent electrical properties . . . **Polypropylene**—lightest of all known materials.

Garlock will work directly to your specifications or, upon request, will gladly assist you in product design and development.

GARLOCK

For complete information contact one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write for Plastics Catalog AD-171, The Garlock Packing Company, Palmyra, N. Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

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Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†DuPont Trademark

TEFLON (above), NYLON, C.T.F.E., DELRIN, other industrial plastics are available from Garlock for a wide range of electrical, mechanical and chemical applications.

WORLD'S LARGEST STOCK OF PLASTICS, such as this Nylon rod and tubing, is located in warehouses convenient to you . . . assures you prompt service any time, anywhere.

DIFFICULT MOLDED AND MACHINED PARTS, like these of Teflon and C.T.F.E., offer no problem to Garlock . . . intricate shapes, thin sections, close tolerances are routine.

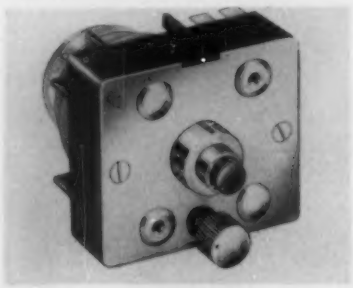
temperature range. Contacts rated 1 amp resistive at 28 v dc, SPST, either make or break. **Consolidated Controls Corp, Bethel, Conn.**

Circle 318 on Reader Service Card

500 F sensor . . .

is self-adhering for instrumentation and temperature control applications. Thermal time constant is less than 1 sec, measures 1¼-in. sq x 0.050 in. thick, weighs less than 4 gm. Resistance is 676 ohm at 76 F. Price ranges from $19.80 for one or two units to $11.90 in quantities of 51 to 100. **Minco Products Inc, 740 Washington Ave N, Minneapolis 1.**

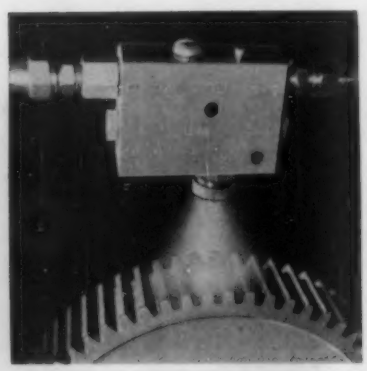
Circle 319 on Reader Service Card



Pushbutton interval timers . . .

allow user to select and repeatedly actuate desired interval. Switch on unit is rated 28 amp or 1 hp at 250 v ac. UL-approved timer is available for 120 or 240 v operation at 50 or 60 cps with intervals of 30 sec and 1, 5, 10, 30, 60 or 120 min. **Haydon Div, General Time Corp, 245 E Elm St, Torrington, Conn.**

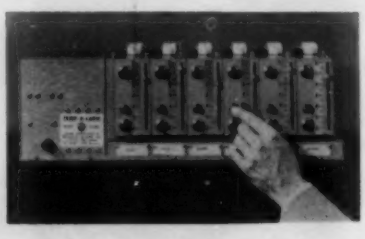
Circle 320 on Reader Service Card



Lube spraying valve . . .

requires 15 to 25 lb pressure and automatically shuts off air when lubricant feed shuts off. Suitable for any oil or grease that can be pumped. For use with ¼ or ⅜ in. tubing. **Trabon Engineering Corp, 28815 Aurora Rd, Solon, Ohio.**

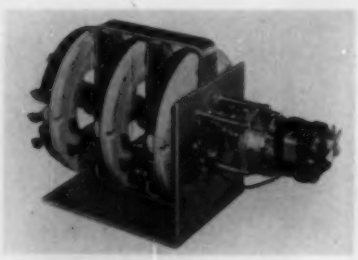
Circle 321 on Reader Service Card



Overheating triggers alarm . . .

when temperature in production unit reaches preset limit. Sends signal to annunciator that causes audible and/or visible alarms to sound either locally, at a remote locaton by use of a telephone line, or both. Each annunciator has an alarm time delay that can be set from zero to 6 hr. Only when danger temperature continues for period exceeding setting on time delay does device sound warning. One device monitors from 1 to 6 production units; another, from 7 to 12. Operates on 115 v, 60 cps, ac. **Walter Kidde & Co Inc, 675 Main St, Belleville 9, NJ.**

Circle 322 on Reader Service Card



Motor-driven rheostats . . .

or variable transformers are for remote control applications or where predetermined rate of resistance or voltage change must be achieved smoothly. Standard drives consist of ac motor with integral gear reducer and cam-operated limit switches to reverse control. Standard assemblies are for horizontal surface mounting. Also available are motor-driven assemblies of ganged transformers or rheostats or combinations of these. Traverse time period of control can be set for specific applications. **Ohmite Mfg Co, 3677 Howard St, Skokie, Ill.**

Circle 323 on Reader Service Card

Tandem hydraulic pumps . . .

consist of two separately piped sections. Larger volume section is available in 20, 31 and 44 gpm sizes; small volume end in 2, 3, 5, 8, and 12 gpm sizes; all at 1200 rpm. All but largest sizes also operate at alternate standard speed of 1800 rpm. Capacity of sections is then increased to 30 and 45 gpm at large sections, 3, 5, 8, and 12 at small end. Largest unit has max capacity of 55 gpm and, like rest of the line, produces 1500 psi pressure with standard hydraulic oils. Volumetric efficiencies are 91%; over-all efficiencies are 86% or better. **Double A Products Co, Manchester, Mich.**

Circle 324 on Reader Service Card

Ball-point mechanical lugs . . .

attach to stranded welding cable by removing 1 in. of cable jacket and tightening ball-point screw down on bare strands. Made of high-conductivity copper, lug barrel is tapped to accept cadmium-plated steel, ball-point screw. In two sizes, to handle No. 4 through 4/0 cable. Available with or without fiber insulating cover. Priced from $1.30 to $2.05, depending on size, for quantities of 250 or more. **Tweco Products Inc, Box 666, Wichita 1, Kans.**

Circle 325 on Reader Service Card

Quick-disconnect valves . . .

are offered in low-pressure (500 psi max) and high-pressure (3000 psi) series in aluminum and stainless steel. Both valves are self-sealing. Said to permit no fluid spillage, no trapped air. **Symetrics Inc, 3100 Airport Ave, Santa Monica, Calif.**

Circle 326 on Reader Service Card

X-Y recorder . . .

has integral ac/dc input and built-in X-axis time base. Operates directly from a transducer, eliminating need for extra ac converter. Dc ranges are reported to achieve accuracy and resolution of better than 0.2%. Input range is 7.5 milliv to 150 v on X-axis; 5 milliv to 100 v on Y-axis. X-axis time base (5 steps) is 7.5 to 750 sec. Input resistance is 200,000 ohm per v. Recorder provides zero offset and vacuum-paper hold-down. Pen speed is 20 in. per sec for each axis. **F L Moseley Co, 409 N Fair Oak Ave, Pasadena, Calif.**

Circle 327 on Reader Service Card

IF A *MINIATURE* OR *INSTRUMENT* BEARING IS NEEDED . . .

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. . . IS THE *SOURCE!*

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.

Retainer Bearing Plain

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Retainer Bearing Shielded

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RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

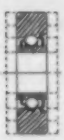
Full bearing (Available plain or flanged)

FULL BEARINGS

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES ➡

	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562



A wafer bearing compared with standard equivalent

UP and WAFER BEARINGS

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

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is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK . . .

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

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Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

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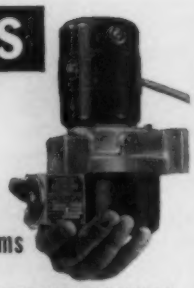
NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, N. H.

PUMPS

that offer a new approach to your design problems



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Miniaturized in everything but power, Oil-Dyne pumps provide new economy and efficiency on standard hydraulic applications . . . make hydraulic actuation possible on applications never before feasible.

Oil-Dyne pumps simplify your design problems by eliminating external directional control valving . . . integral valving permits changing the direction of cylinder travel by simply reversing the motor. Pressures to 3,000 lbs. (5,000 lb. peaks); available with or without pressure switches and/or relief valves. Write for illustrated catalog.

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CIRCLE 204 ON READER SERVICE CARD

SAVE TIME

WITH KAMLOK QUICK COUPLERS

CUT YOUR MAINTENANCE COSTS

Save production time by replacing hose and pipe connections with Kamlok Quick Couplers. Used wherever hose and pipe connections are periodically uncoupled. Fast . . . Safe . . . Sure. No tools needed. Just fit together and pull the cam arms down. Lock securely in place. Leakproof gasket cannot fall out. All Kamloks 100% master gauged for complete interchangeability.

KAMLOKS are available from stock in bronze, aluminum, stainless steel, monel and semi-steel from ½" through 6" sizes. 39 different styles to choose from. Specials to fit your needs. Get full detailed information.

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DESIGN LITERATURE

A History of Science, Technology and Philosophy in the 16th & 17th Centuries

A WOLF, Harper Brothers (Torchbooks) 49 E 33rd St, New York. 2 vol, each 5¼ x 8, 680 pp. $1.95 (paperback).

The 200 years encompassed by these two volumes marked perhaps the rebirth of scientific thought. From the era of Greek-Roman scientific and philosophical teachings until the 16th century there was practically no scientific advancement. Concepts of Copernicus, Galileo, and Newton, to name but a few, were the seeds for the eventual Industrial Revolution, and a new way of life. These volumes make a courageous attempt to present the historical developments of such fields as mathematics, mechanics, physics, meteorology, chemistry, geology, biology, psychology and philosophy. Herein lies the rub of many a scientific history—an attempt to cover too much.

Fortunately, Mr Wolf did not attempt to discuss the social effects of these scientific developments; he limited himself to a straight and readable history. These inexpensive paperbacks (of a work originally published in 1950) are interesting background material for any science historian.—BAL

New Forces in American Business

DEXTER M KEEZER, director, and five associates in McGraw-Hill Economics Dept. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5⅜ x 8, 278 pp. $4.75.

McGraw-Hill editors have one great advantage in the field of economics—the services of a staff of specialists headed by Dexter Keezer. (Dr Keezer is wont to say that he has the advantage of consulting a number of authorities—600 editors—so years of association have done nothing to impair a mutual respect.) The result is practical economics—business interpretation and forecasting that is accurate and reliable. This book presents the fundamentals of this economic outlook.

As practical (meaning business) rather than academic economists, the authors admit to a preference for optimism, but this reviewer has seen no evidence to indicate bias, unless it is in the direction of making economics readable and understandable. In fact, you may detect a puckish glint behind the polished phrases and a glint behind the horn-rimmed glasses as you read, although the book does not (and quite properly) include some of the incidental results of research to which McGraw-Hill editors are treated. There is not, for example, a chapter on how to choose a Christmas necktie, or a discussion of exotic forecasting methods, or even a paragraph on how economists hedge with doubletalk. This is a straightforward presentation of the business outlook for the 60's, in simple language, told by people interested in their subjects and willing to stick out their collective neck.

Here are predictions on investment, reasearch, demand, marketing trends, small business, inflation and international trade. And they're firm predictions, without quibbling and hedging, endangered only by the human perverseness and eussedness that could blow everything ski-high.—EJT

Analysis of Electric Circuits

EGON BRENNER and MANSOUR JAVID, City College of New York. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 703 pp. $9.50.

This college-level text has an approach different from the conventional sequence of "dc circuits," "ac circuits," and "transients." Instead, it treats the circuits more generally as follows:

First it describes linear systems with differential equations in the time domain. This is the starting point for all analysis. Other network descriptions and methods of solution are related to the differential equation.

Next, it gains insight into the behavior of circuits. In particular the relationships between forced (steady-state) and free (transient) response are explored fully, culminating in the study of networks through pole-zero configurations.

It uses fundamental principles rather than routine shortcut procedures; avoids habit of writing mesh

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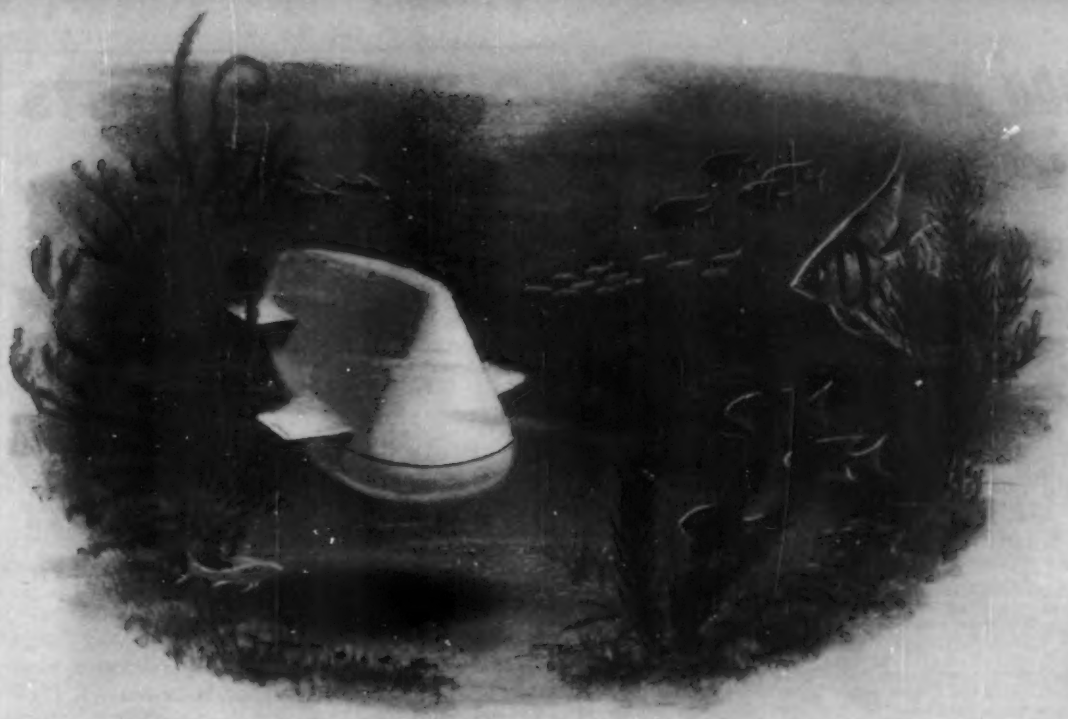

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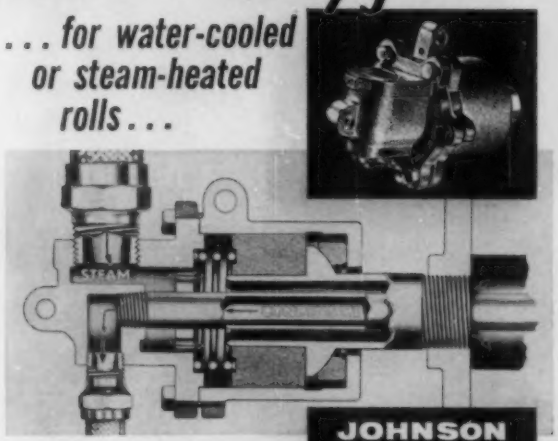

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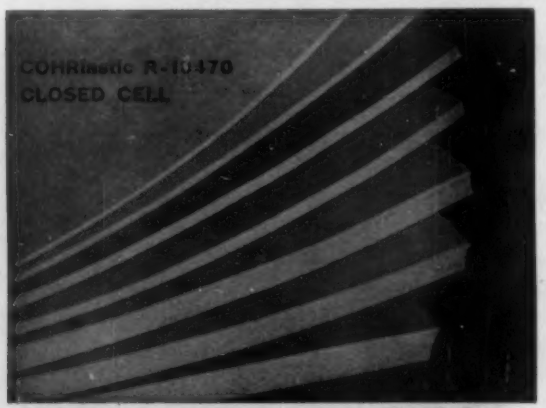

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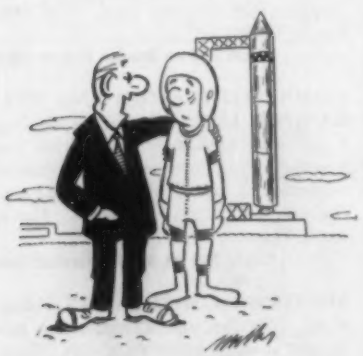
Remaining chapters cover complex numbers, source-free R-L-C circuit, circuits with sources, network functions, poles and zeros, sinusoidal steady state, network theorems, three-phase circuits, magnetic coupling, harmonic analysis and Fourier series.

Nomography

ALEXANDER S LEVENS, Professor of Mechanical Engineering, Univ of Calif. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6½ x 9½, 296 pp. $8.50.

This book provides a modern working knowledge of the basic theory and construction of charts involving straight-line scales, curved scales, and combinations of the two. This new edition also offers three completely new chapters on: circular nomograms, projective transformations, and the relation between concurrency (Cartesian) and alignment nomographs with applications to experimental data.

The mathematical developments for the various type forms throughout the book have been simplified, and many new problems and examples are introduced. The appendix contains 58 nomographs in such fields as statistics, tests and measurements, various branches of engineering, physical and biological sciences, food technology, heat transfer, satellite launching, radioactivity.



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ABSTRACTS FROM THE LITERATURE

Metals at High Temperatures

The newer high-temperature test methods of determining elastic moduli, tensile behavior at high strain rates, and hot hardness are described and experimental data analyzed. Effects of grain size, composition, and various transformations are discussed. Relationships between hardness and tensile strength, creep and creep-rupture behavior are summarized.

"Survey of Various Special Tests Used to Determine Elastic, Plastic and Rupture Properties of Metals at Elevated Temperatures," F. Garofalo, US Steel Corp; ASME paper 59-A-112, ASME 29 W 39th St, New York 18.

Lubrication by Solids

Mechanism of lubrication is described and various types of solid lubricants are classified.

"Lubrication by Solids," J. Gaensheimer, Stamford, Conn; presented at Seminar on Friction, Lubrication and Wear, Burgenstock, Switzerland, Sept 17-18. Available from Alpha-Molykote Corp, Stamford, Conn.

Photoelastic Approach to Transient Stress

Distribution of dynamic stress was studied by applying photoelastic techniques to low-modulus materials, in particular Hysol 8705. A complete study of this urethane-rubber compound's mechanical and optical properties was made under both static and dynamic loadings. It is reported that the techniques employed made it possible to obtain whole-field representations of the stresses.

"A Photoelastic Approach to Transient Stress Problems Employing Low-modulus Materials," Dally, Riley and Durelli, Armour Research Foundation; ASME paper 59—A-10, ASME 29 W 39th St, New York 18.

Lubricating-grease Properties

One of the factors affecting properties of lubricating grease is the size and shape of the thickener particles. The effect of the length-to-width ratio of these particles on mechanical stability, age-hardening, and leakage of grease was studied. Four greases were made from lithium hydroxy stearate and a mineral oil. The greases were alike in thickener concentration and consistency but differed in thickener-particle dimensions as measured from electron micrographs. Increases in length-to-width increased mechanical stability and leakage and reduced age-hardening. Although observed only with lithium-soap greases, the same trends should occur with other greases.

"Effect of Thickener-particle Dimensions on Lubricating-grease Properties," A. C. Borg and R. H. Leet, Standard Oil Co, Whiting, Ind; Lubrication Engineering, Nov '59, 5 N Wabash Ave, Chicago 2.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 79.

CONTROL DEVICES—Catalog GEC-1260D, 72 pp. Lists selection information for motors from ¼ through 200 hp, starters, heaters and pushbutton stations necessary for control of motors. Includes wiring diagrams, dimensions and application information. General Electric Co, Schenectady 5.

Circle 340 on Reader Service Card

MOLDED-CASE CIRCUIT BREAKERS—Bulletin 5001-1A, 40 pp. Gives ratings, specifications and operating characteristics of line of molded-case circuit breakers. Two-page reference chart pictures each type of breaker together with pertinent selection and performance information. I-T-E Circuit Breaker Co, 1900 Hamilton St, Philadelphia 30.

Circle 341 on Reader Service Card

STEEL ABRASIVE PERFORMANCE—Bulletin 903-D, 20 pp. Performance and statistical data compiled in abrasive re-

(Continued on page 76)

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search and experimentation is discussed. Charts, graphs, photomicrographs are included. Wheelabrator Corp, 1073 S Byrkit St, Mishawaka, Ind.

Circle 342 on Reader Service Card

FIXED TUBE BUNDLE HEAT-EXCHANGERS—Catalog 1258A, 16 pp. Specifications, pressure ratings, descriptions of individual models and operational principle, dimensions. Young Radiator Co, Racine, Wis.

Circle 343 on Reader Service Card

POWER STEERING SYSTEMS—Bulletin M5110, 16 pp. Covers features, dimensions and specifications of line of power steering systems and accessories. Vickers Inc, 1402 Oakman Blvd, Detroit 32.

Circle 344 on Reader Service Card

ENCLOSED SWITCHES—Catalog 77b, 16 pp. Covers high-performance, sealed, environment-proof and hermetically sealed switches for aircraft, mobile, marine and railway applications. Includes information on mounting, actuators, electrical ratings, operating characteristics and contact arrangements. Micro Switch, Freeport, Ill.

Circle 345 on Reader Service Card

CAST BRONZE ALLOYS—Brochure, 4 pp. Chemical and physical specifications of 29 cast bronze alloys. Chart indicates compressive strengths of selected alloys and how these properties vary with metal thickness. Renewal Service Inc, 17th and Lehigh Aves, Philadelphia 32.

Circle 346 on Reader Service Card

ZIPPER TUBING—Catalog Z-2, 4 pp. Discusses characteristics, construction, specifications and applications. Alpha Wire Corp, 200 Varick St, New York 14.

Circle 347 on Reader Service Card

DATA-PROCESSING EQUIPMENT—Brochures (3). Features, specifications and applications of high-speed digital plotter (4 pp); a tape preparation and editing console (6 pp); and logic switches (8 pp). Tally Register Corp, 5300 14th Ave NW, Seattle 7.

Circle 348 on Reader Service Card

LAMINATED PLASTICS AND VULCANIZED FIBER—Condensed Catalog, 8 pp. Basic-application information and typical physical, mechanical and electrical properties of laminated plastics and vulcanized fiber. Taylor Fibre Co, Norristown, Penna.

Circle 349 on Reader Service Card

MECHANICAL SHAFT SEALS—Folder, 4 pp. Describes and illustrates two new designs in water pump shaft seals. Shows cutaway views of seals and includes information on size, applications and sealing

(continued on page 77)

DESIGN LITERATURE.....continued

principle. Rotary Seal Div, Muskegon Piston Ring Co, Sparta, Mich.

Circle 350 on Reader Service Card

REFRIGERATION AND AIR-CONDITIONING CONTROLS–Folder, 6 pp. Outlines ratings, applications and specifications of nine motor and commercial controls. Texas Instruments Inc, Metals & Controls Div, Spencer Products Group, 34 Forest St, Attleboro, Mass.

Circle 351 on Reader Service Card

THERMOCOUPLE TERMINAL BOXES–Bulletin 28, 4 pp. Describes cast iron and sheet steel boxes. Lists dimensions and capacities of line of weatherproof multijunction thermocouple terminal boxes. Thermo Electric Co Inc, Saddle Brook, NJ.

Circle 352 on Reader Service Card

HYDRAULIC EQUIPMENT–Folder, 4 pp. Tabulates specifications of power pumps, valves, cylinders and hand-operated pumps. Discusses applications of equipment. Dynex Inc, 777 Dynex Dr, Pewaukee, Wis.

Circle 353 on Reader Service Card

MALLEABLE, TAPERED ROLLED-PILLOW BLOCKS–Catalog BU-102-A, 4 pp. Specifications, dimensions and load ratings of tapered roller-bearing units. Includes cutaway view and dimensional drawings. Browning Mfg Co, Maysville, Ky.

Circle 354 on Reader Service Card

RESONANT-REED FREQUENCY METERS–Bulletin 32-32, 20 pp. Covers sizes, ranges, design, characteristics and prices of resonant reed frequency meters. James G Biddle Co, 1316 Arch St, Philadelphia 7.

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PNP PHOTOTRANSISTORS–Brochure G-190, 8 pp. Describes line of PNP germanium alloy junction phototransistors.

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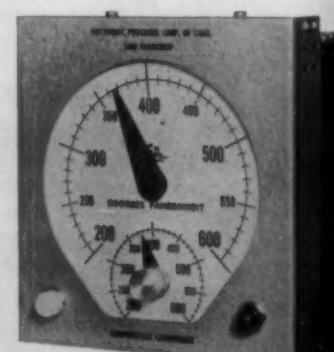

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PUSHBUTTON SWITCH ASSEMBLIES—Data sheet 150 B, 8 pp. Introduces three new assemblies with special circuit to produce one square wave pulse regardless of operating speed. Contains photos, circuit diagram, tables, graphs, application and mounting information, list prices. Micro Switch, Freeport, Ill.

Circle 357 on Reader Service Card

RUBBER-TO-METAL BONDED GASKETS—Brochure, 8 pp. Presents physical properties, typical applications, seal configurations, design, dimensions, material selection and general description of custom-designed rubber-to-metal bonded gaskets. Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Calif.

Circle 358 on Reader Service Card

VALVES—Booklet, 4 pp. Contains information on construction, dimensions, materials, operating principles and ordering for line-of-check, relief, shutoff, plug and custom valves. Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena, Calif.

Circle 359 on Reader Service Card

DIRECT-LIFT AND SOLENOID-OPERATED VALVES—Bulletin S-1, 4 pp. Covers construction, operation, performance and dimensions of full-ported, direct-lift valves for pressures from zero to 10,000 psi. Atkomatic Valve Co Inc, 545 W Abbott St, Indianapolis 25.

Circle 360 on Reader Service Card

ELECTRONIC RESINS, BONDING AGENTS—Bulletin 121, 4 pp. Contains selector charts for potting compounds, coatings, foams and bonding agents. Plastic Associates, 185 Mountain Rd, Laguna Beach, Calif.

Circle 361 on Reader Service Card

GENERAL-PURPOSE RELAYS—Bulletin 99, 2 pp. Specifications and dimensions of general-purpose and plate-circuit relays. Artisan Electronics Corp, 171 Ridgedale Ave, Morristown, NJ.

Circle 362 on Reader Service Card

ISOLATING SHOCK, VIBRATION—Bulletin 59-04-4, p pp. Features and performance information on shock and vibration isolators. With performance curves and cutaway views. Barry Controls Inc, 700 Pleasant St, Watertown 72, Mass.

Circle 363 on Reader Service Card

SOLENOID-LOCK MECHANISM—Bulletin 18, 1 pp. Describes application of solenoid locking mechanism to standard

(continued on page 79)

rotary switches. Includes ratings. Electro Switch Corp, King Ave, Weymouth, Boston 88.

Circle 364 on Reader Service Card

LIMIT SWITCHES—Data sheet 166, 2 pp. Describes two oiltight maintained-contact yoke actuator switches. Includes photos, dimensional drawings, characteristics, electrical ratings and price information. Micro Switch, Freeport, Ill.

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LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

HOT-DIP ALUMINUM COATING—Brochure, 4 pp. Discusses process to prevent atmospheric corrosion and high-temperature oxidation and scaling of ferrous parts. Arthur Tickle Engineering Works Inc, 21 Delevan St, Brooklyn 31.

INDUSTRIAL CONTROL—Catalog, 88 pp. Describes line of industrial controls, including automatic temperature, pressure, level and flow controls, as well as counters, switches and automation controls. Also covers industrial actuators, combustion instrument controls, controller indicators and pressure indicators, electrohydraulic actuators. General Controls Co, 801 Allen Ave, Glendale 1, Calif.

ELECTRONIC INSTRUMENTS—1960 catalog, 32 pp. Describes and illustrates instruments for electronic, biological and chemical measurement and control. Includes specifications and performance information, schematic diagrams and application circuits. Keithley Instruments Inc, 12415 Euclid Ave, Cleveland 6.

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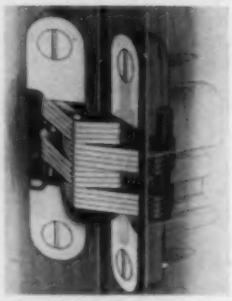

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Equation provides time-saving way to find natural frequency. Jan 11 Circle P 27

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A tabular way to obtain maximum information from a minimum of tests. Dec 21 Circle P 24

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13 Ways to Cut Drafting Costs
List of helpful modern methods, materials and equipment that save money. Step 28 Circle P 8

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Modernize Now
Why and how to modernize the engineering design function; how to calculate R & D investment, costs and manpower needs; engineering laboratory, drafting equipment; company library; model shop. R 19

Sandwich Panel Materials
Selection guide for core materials, facings and adhesives—presented in tabular form. Core materials include vegetable mineral and plastic in solid, honeycomb and foam. Data on facings, cover metal, wood and plastic. Adhesives table lists properties for the 14 most widely used. R 18

The Engineer Comes into His Own (3/31/58)
Summary of current thinking on what makes him tick; his growing ties with other sciences and human beings . . . and what tomorrow holds for him. R 17

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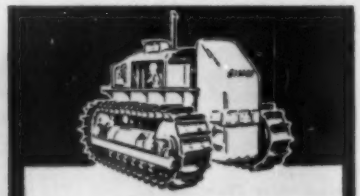

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Every advertisement printed in the Employment Opportunities Section is duly authorized.

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- Uses standard V-Belts.
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- Changes speed quickly while machine is running.
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- Minimum wearing parts—no expensive replacements.
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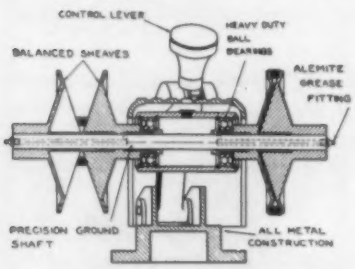

This cut-away sketch shows the practicality and simplicity of the Select-O-Speed's design. Nothing complicated, just two variable pitch sheaves mounted on a pivoted shaft. No internal mechanism—no intricate parts. Shifting the control lever causes a momentary variation in tension between the driving and driven belts which changes the sheave pitch diameters and the driven speed.

Get the facts about the Select-O-Speed. Tell us about your application. We'll give you our recommendations. Request Bulletin 118.

LOVEJOY FLEXIBLE COUPLING CO.
4841 W. Lake St., Chicago 44, Illinois

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EMPLOYMENT OPPOkTUNITIES.72, 82-83

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Products Index appears on P. 84

No. 9 of a series

Eastman 910 Adhesive solves another production bottleneck

The Rhine Craft Corporation, of Brooklyn, N. Y., introduced recently a line of costume watch jewelry...pendants, pinfarbs and bracelets.

Key to low manufacturing costs was a fast, simple method of mounting the watch case to the jewelry base. Soldering proved too slow and costly.

The answer was found in quick-setting, high-strength Eastman 910 Adhesive.

The adhesive is applied to the jewelry base and the watch case is set in place. *Within minutes, a permanent bond is formed.* The bond is so strong the gold-plating separates from the watch case when it is forced out of the jewelry base.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9101 Irvin Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. P-1, Kingsport, Tenn. (Not for drug use)

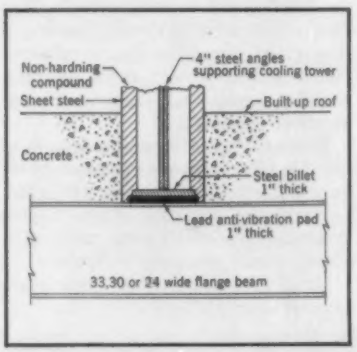
the LEAD newsletter

Lead Controls Vibration and Noise

Lead plays a vital role in the success of many of the more advanced developments in sound attenuation and vibration control.

New Skyscraper Depends on Lead To Damp Railroad Vibration

Building a towering office building over a dense network of railroad tracks . . . as was done in the case of the new Union Carbide skyscraper . . . presented a difficult problem of vibration control. It was solved by the use of lead-asbestos pads . . . a technique used by the architects of many of the adjoining buildings in New York City's Grand Central Station area. These lead cushions utilize lead's unmatched vibration damp properties. They'll substantially reduce vibration for the life of the building. These lead vibration pads serve an amazing variety of industries. High speed printing presses, for example, also make excellent use of lead's vibration damping properties.



Lead Isolates Vibration and Noise of Air Conditioning Unit

The huge air conditioning unit atop another new skyscraper at 575 Lexington Avenue in New York City keeps the building's occupants comfortably cool . . . quietly, thanks to lead. Anti-vibration pads made of lead-asbestos shield the building from the noise and vibration of this huge unit. Because they and the cooling tower's supporting steel columns can be placed in position while the steel work is in progress . . . in contrast to other methods, which would necessitate waiting until the concrete had been poured . . . the lead-asbestos pads shortened installation time considerably.

Jets, Helicopters, Use Lead

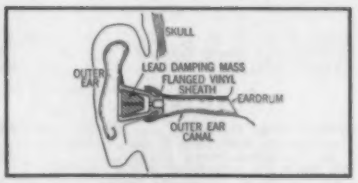
Lead impregnated vinyl has found wide usage in abating noise in conventional and jet airliners as well as in helicopters. The special ability of lead to absorb or damp sound in the low frequency range . . . makes it ideal for shielding the occupants of the aircraft from ear splitting engine noise. In this product, lead-powder-impregnated vinyl is employed to coat a cotton duck or woven glass fabric, thus adding the strength and flexibility characteristics of vinyl, glass, and cotton to the noise isolation qualities of lead.

Electric Typewriters Damp Vibration with Lead, Too

Lead impregnated vinyl also is used in the latest electric typewriters to damp the high frequency vibrations which occur in the keyplate and paper table. For ease of application, the material comes with a pressure sensitive adhesive backing.

Lead Controls Vibration in "White Noise Room"

To test the effects of vibration on the drift rate of gyros and accelerometers, Minneapolis-Honeywell researchers have created a "White Noise Room" at their Inertial Guidance Center. In this room, where the mechanical noise and vibrations of missiles and space ships are exactly duplicated, lead is used as a damping mass to confine vibration and noise to the test area and to dissipate energy. In addition to minimizing vibration, non-ferromagnetic lead eliminates any magnetic field disturbances that could interfere with other work in the area.



Navy Uses Lead Ear Plugs

During World War II, the Navy sought an ear plug capable of preventing ear damage and concussion from the tremendous vibration generated by the firing of their big guns. The solution was found in a lead-plastic ear plug. The lead mass keeps the shock wave of sound from moving into the ear en masse. Instead, it lets the pressure of the outside ear build up to meet it gradually . . . slowly enough, in fact, for the shock wave to pass before the pressure inside the ear can become dangerous. The plastic is used to seat the plug in the ear without discomfort. In a quiet environment, a normal speaking voice can be heard through a perforation in the ear plug. Proof of the success of this lead ear plug is attested to by the fact that the Navy is still using them.

Lead Has Many Uses

You'll find lead applications that range from vibration and noise suppression to glazing fine china . . . from swimming pool reactors to superconductivity . . . from corrosion resistant paints to portable reactor shielding. Lead shows a remarkable ability to keep pace with the latest technological developments in a wide variety of fields. Much of this is due to the continued scientific attention devoted by L.I.A. researchers to investigating new uses, techniques, and developments.

For detailed information, write to: *Office of Technical Information, Lead Industries Association, 60 West 42nd Street, New York 17, N. Y.* 1973

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Issue of January 11, 1960

Product Engineering

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Issue of January 11, 1960

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315—Audible Alarm Device

316—Maintained Contact Limit

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319—500 F Sensor

320—Pushbutton Interval Timers

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323—Motor-driven Rheostats

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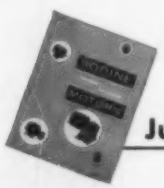

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